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# BUREAU OF SHIPS GROUP

# TECHNICAL INSPECTION REPORT.

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⑪ 1947

Classification (~~Confidential~~) (Changed to **CONFIDENTIAL**)  
By Authority of Joint Chiefs of Staff (Action by AFM #2)  
By John Beagle Capt Date 1 May 51  
AFSWP

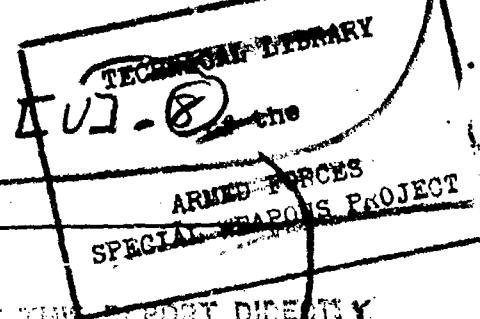
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U.S.S. SKATE (SS305)

# TESTABLE

# VOLUME 1



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# JOINT TASK FORCE ONE

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JUL 1964

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BUREAU OF SHIPS GROUP  
TECHNICAL INSPECTION REPORT

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By authority of Joint Chiefs of Staff (Action 10 Apr 47)  
*John Beggs Capt* Date 1 May 51  
*AFSWP*

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SUBMITTED:

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Commander, U. S. N.

APPROVED:

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F. X. Forest, Captain, U. S. N.  
USS SKATE (SS-395)

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Page 1 of 140 Pages

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## TABLE OF CONTENTS

### VOLUME I

	PAGE NO.
Ship Characteristics Sheet - - - - -	3
Midship Section - - - - -	4
Overall Summary - - - - -	5
Hull Technical Inspection Report (Section I) - - - - -	13
Machinery Technical Inspection Report (Section II) - -	46
Electrical Technical Inspection Report (Section III)- -	75
Ship Measurement Data - - - - -	95
Commanding Officer's Report (Appendix) - - - - -	98

### VOLUME II

Photographic Section - - - - -	2
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SECRET

USS SKATE (SS305)

Page 2 of 140 Pages

U.S.S. SKATE (SS305)

SHIP CHARACTERISTICS

Building Yard: Mare Island Naval Shipyard.

Commissioned: 15 April 1943.

HULL

Heavy Hull Construction.

Length Overall: 311 feet 8 inches.

Length (between perpendiculars): 307 feet 0 inches.

Beam (extreme): 27 feet 3 inches.

Beam (molded): 27 feet 1 3/4 inches.

Height (lowest point of keel to top of periscope  
supports): 47 feet 2 inches.

Drafts (at time of test): Fwd. 15 feet 0 inches.  
Aft. 15 feet 7 inches.

Standard Displacement: 1525 tons.

Displacement (at time of test): 1815 tons.

MAIN PROPULSION PLANT

Main Engines: Four Fairbanks-Morse, 9 cylinder,  
Type 38D8.

Auxiliary Engine: Fairbanks-Morse, 7 cylinder,  
Type 38D5.

Main Motors and Generators: Elliott.

Main Storage Battery: Exide.

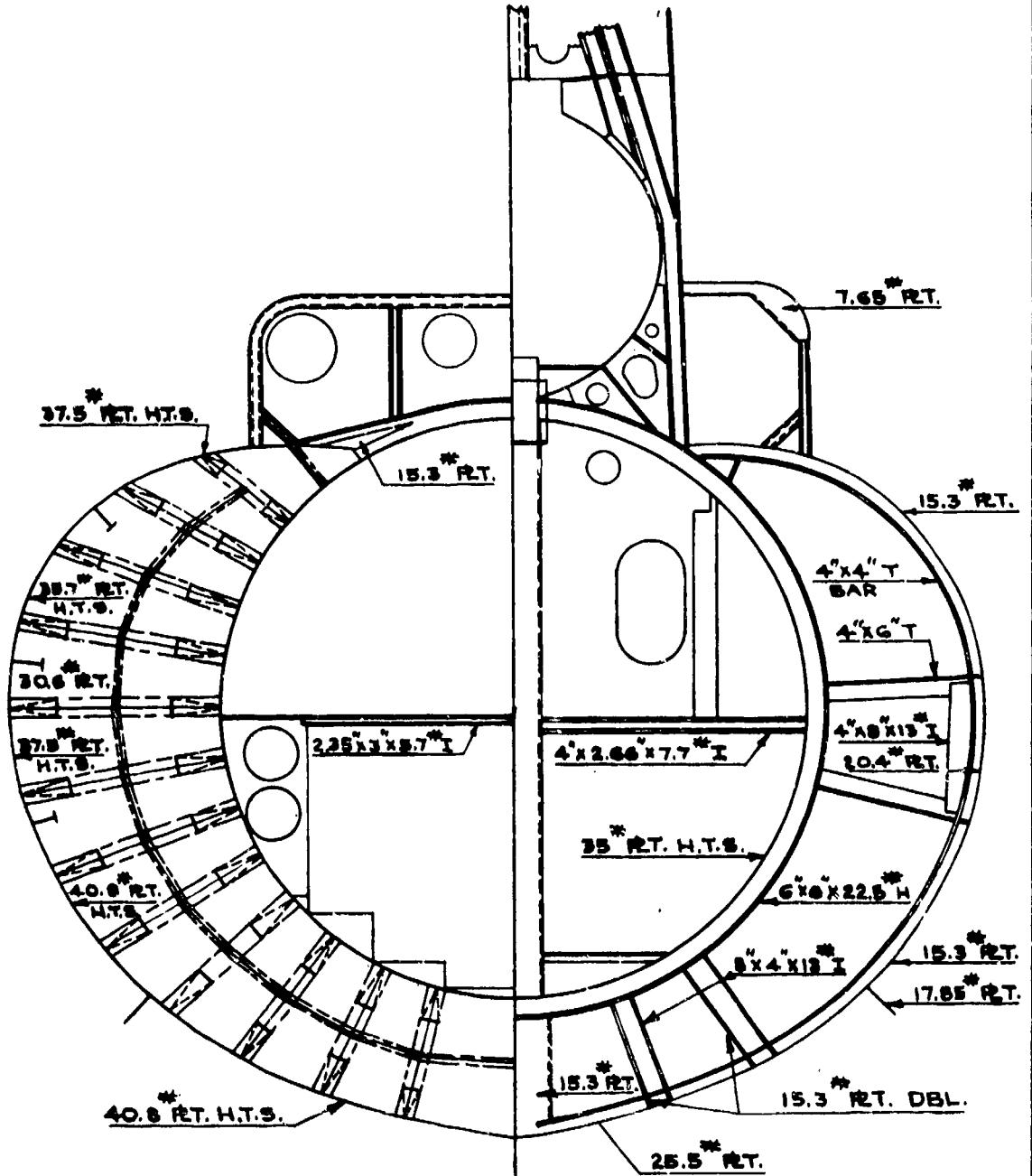
Main Controls: Westinghouse.

Reduction Gears: Westinghouse.

Diesel Electric Drive.

~~SECRET~~ USS SKATE (SS305)

Page 3 of 140 Pages



**TYPICAL SECT. AT FR. 69  
LOOKING AFT**

**TYPICAL SECT. AT FR.53  
LOOKING FORD.**

TEST A

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**U.S.S. SKATE (SS 305)**

PAGE 4 OF 140

## TECHNICAL INSPECTION REPORT

### OVERALL SUMMARY

#### I. Target Condition After Test.

- (a) Drafts after test; list; general areas of flooding, sources.

Before the test the drafts were 15' - 0" forward and 15' - 7" aft. The ship had a 1/2° list to starboard. Draft readings after the test are not available as the ship was beached before the Initial Boarding Team was permitted to make an inspection. After the vessel was hauled off the beach the readings were 16' - 2" forward and 17' - 9" aft. There was a 2 or 3 degree list to starboard due to flooding of six main ballast tanks and the displacement of damaged structure to starboard. It is believed that one or two of the flooded tanks had been blown during the unbeaching operation.

- (b) Structural damage.

The pressure hull, including the conning tower, is intact and undamaged except for the port side of frame 55 just above the tank top where 24 inches of the frame welding cracked. This was due to the blast pressure on the conning tower and shears above; the pressure hull plating is not distorted or damaged. There is no structural damage to compartments. The ballast tanks are intact insofar as structure is concerned, having suffered only minor denting. All damage of consequence is confined to the area above the pressure hull where the superstructure and weather deck are demolished from frame 10 aft to the stern. The conning tower fairwater and bridge are completely demolished. The non-watertight bow, pivoting at frame 10, appears to have moved to starboard through a very small angle (2 or 3 degrees). The stern above the waterline aft of frame 132 is displaced parallel to the hull axis a distance of 8 inches and crushed in on the port side. The periscope and radar shears are bent about 15° and 25° to starboard respectively, as a result of failures at the connection to their foundations. Aft of the conning tower most of the decking,

SECRET

USS SKATE (SS305)

the majority of the free-flooding superstructure, many fittings, and most of the piping was bent, damaged by blast, or blown over the side. The bridge structure was opened up and folded together upon itself in front of the conning tower. Nearly half of the superstructure forward was wrecked. See page 2 of Volume II for a general view of this damage.

(c) Other damage.

Both periscopes, the radar masts, bow buoyancy vents, No. 7 main ballast tank vent and the main induction valve are inoperable due to distorted shafting. Nos. 2, 4, and 6 torpedo tubes are inoperable due to leaky or ruptured impulse air lines and Nos. 7 and 8 tubes are inoperable due to distorted shutters. The debris and torn metal topside had sheared, cut, or torn loose practically every cable leading through the superstructure. The sidelights were shattered. The stern light was missing. The after windlass was inoperable due to the fact the drum and its shaft had been bent over by the blast.

Electrical equipment was operable except for the following items:

1. The main gyro compass.
2. The auxiliary gyro compass.
3. The voltage and speed regulators for the three I.C. motor-generator sets (ability to hand control was not affected).
4. The running lights.
5. Instruments on the bridge (due to parted cables).
6. Power drive on after gyro setting indicator regulator.
7. 1 and 7 MC bridge reproducers.

All electronic equipment was inoperable except the WCA sonar equipment.

All ship control and propulsion machinery inside the pressure hull was undamaged and operable when tested.

SECRET

USS SKATE (SS305)

II. Forces Evidenced and Effects Noted.

(a) Heat.

A heat flash appears to have come from about 220° relative. The scorching mentioned in paragraph I above is believed to have affected only the outside coat of paint. The damage to topside light plating is so severe that the remaining evidence of paint scorching is not sufficient to form the basis for any significant conclusions.

There was no evidence of heat having affected any equipment inside the pressure hull. Topside cables in a few instances, particularly those high on the superstructure and on the periscope shears, had a light covering of char or soot which could be rubbed off with the fingers, but in no case was insulation damaged due to heat alone. Some scorched paint remains in protected spots but it appears that scorching was minor and that most of the scorched paint was blown off. This effect seemed to be less on the SKATE than on other target submarines.

(b) Fires and explosions.

There is no evidence of fire or explosions.

(c) Shock.

Damage from shock was not extensive. Torpedo tube cradles were distorted. This distortion is of such nature as to indicate that the ship (at least the two ends) moved violently and suddenly to starboard. If such motion is assumed, the distortion of the torpedo cradles is due to the inertia of the torpedoes stowed in these cradles. Mountings of the QLA sound stack in forward torpedo room and TBL transmitter in radio room failed. These failures could have been due to extreme rolls of vessel. Shock is believed the cause of failure of the upper support bearing of the sound stack after bearing repeater in the conning tower, clock lens in the after engine room, shattered hard rubber battery

SECRET

USS SKATE (SS305)

ventilation duct in the forward battery tank, and shattering of 6 light bulbs in the after torpedo room. A combination of shock and roll caused a spillage of mercury from both the main gyro compass and the auxiliary gyro compass. Shock was the probable cause of the loss of adjustment on the voltage and speed regulators for three I.C. motor-generators and their failure to function after the test. Roll and shock together caused the shattering of the threads on tie-rod nut holding battery cells of the forward battery.

(d) Pressure.

The salient force causing damage appears to have been a blast or high velocity wind of relatively long duration, and of such intensity as to apply a high pressure to exposed surfaces parallel to the wave front. This wind demolished all the topside structure and may have caused the displacement of the non-watertight stern structure, but caused no direct damage to the pressure hull. It appears to have come from the port quarter.

The exposed tank top plating on the port side aft of frame 70 was dished somewhat between frames, apparently as a result of pressure. Between frames 70 and 75 port (in way of No. 5 fuel ballast tank) there is one continuous dent in the plating and frames which has a maximum deflection of six inches. There is no convincing evidence that this dent was caused by the falling of some heavy object. It is therefore assumed to be the result of pressure. The explanation of why this particular area is dished so much more than adjacent similar structure could lie in the fact that between frames 73 and 78 the tank top plating is overhung by a gun sponson which may have locally intensified the pressure by reflecting the wave down onto the tank top.

(e) Effects apparently peculiar to the atom bomb.

Besides the heavy blast effect discussed above, the SKATE was rendered slightly radioactive, which required three days to decay to the point where the crew could reboard with safety. There are also indications, such as slight spillage of acid from the cells of the batteries, that the ship took an extremely heavy roll.

SECRET

USS SKATE (SS305)

III. Effect of Damage.

(a) Effect on machinery, electrical and ship control.

Except that the bridge and most mooring fittings were blown away, the structural damage had no vital effect on surface operation. After removal of the manhole cover in the top of bow buoyancy tank in order to vent this free-flooding tank, the ship could probably have submerged. The normal bow buoyancy valves could not be opened due to badly distorted linkage. In the event of submerging the main induction would have flooded (via the fracture at the base of the main induction valve and the space between the operating shaft for this valve and its guide bearing), thus roughly compensating for the weight lost in topside structure. However, at any speed other than dead slow, submerged resistance would have been enormously increased and control of the vessel difficult if not impossible due to the unsymmetrical resistance of the damaged structure. The periscopes would have been useless for observation and there would probably have been numerous minor leaks as a result of damaged topside fittings. The ship was operated on the surface for approximately 3 hours underway to test main propulsion machinery in all combinations. This operation was satisfactory and no change in propulsion and ship control machinery had taken place. See photograph on page 3 of Volume II.

(b) Effect on gunnery and fire control.

It may be possible to fire numbers 1 3, 5, 9 and 10 torpedo tubes although misalignment of the shutters on tubes 9 and 10 is suspected. The remaining five tubes were out of action, for reasons described in paragraph I (c) above. Only one gun was mounted and this damaged beyond use. Had the other guns been mounted they would probably be out of action due to interference from demolished structure if not actually damaged. Fire control is restricted to input from the JK-QC sound gear, as periscopes, radar antennae and TBT's are useless.

(c) Effect on watertight integrity and stability.

The watertight integrity of the pressure hull is

SECRET

USS SKATE (SS305)

not affected except for minor leaks due to damaged topside fittings. Main ballast tanks Nos. 2B, 2C, 2D, 6B and 6C flooded slowly to the waterline as a result of damaged salvage valves. Main ballast tank No. 7 flooded as a result of a damaged main vent valve. The total loss of reserve buoyancy was 35%.

(d) Effect on personnel and habitability.

Aside from possible radiological casualties, it is estimated that all topside but no interior personnel would have been lost. Habitability within the ship is 100% and no noxious gases were detected. (The hydrogen found in the battery compartments is believed to be only the accumulation of four days normal concentration). Topside habitability is virtually 100% destroyed as far as fighting or operating the ship in a seaway is concerned.

(e) Total effect on fighting efficiency.

The one installed gun, a minimum of one half the torpedo tubes and almost all means of obtaining fire control data were destroyed. The ship could not operate submerged (except possibly to a very minor extent) and surface operation in the open sea would be all but impractical. It is therefore estimated that the fighting efficiency was reduced by 90%.

#### IV. General Summary of Observers' Impressions and Conclusions.

The SKATE was moored on the surface at a distance of approximately 400 yards from the center of the burst. At this range, the force of the blast was sufficient to completely demolish the non-watertight structure above the waterline but caused little or no damage to the pressure hull. This is exactly the reverse effect from that of a depth charge which attacks only the pressure structure. It is considered that the water provided excellent protection, even for light structure below the waterline, and that, had the submarine been submerged, she would have suffered very little if any damage. However, there can be little doubt that a submarine on the surface would be most effectively

SECRET

USS SKATE (SS305)

put out of action by an atomic bomb explosion such as that of Test A at the range prevailing for that test. It is believed that if unmolested, the ship could have proceeded back to port through moderate seas. It is estimated that a good submarine repair yard could restore the ship to her original condition in four weeks or less.

V. Preliminary General or Specific Recommendations of Inspection Group.

To permit submarines to better withstand the blast effect of the atom bomb, it is necessary that topside structure fittings and hull openings be reduced to an absolute minimum and the unavoidable remainder strengthened and/or protected as much as weight will permit. Such a trend is also desirable from the viewpoint of increasing submerged speed. If submarines abandon surface operation in the open sea much of the top hamper will lose its function and can be automatically eliminated. The rest should be pared to the bone, by drastic redesign of the entire ship if such is necessary.

Specific recommendations to accomplish the above are as follows:

1. Reduce surface silhouette by reducing height of periscope and radar mast supports and full length superstructure. Wood deck should be entirely eliminated and plating above pressure hull should be faired, rounded, fairly heavy and only high enough above pressure hull to enclose absolutely essential external fittings.
2. Eliminate as many as possible of pressure hull openings and external hull fittings including salvage fittings.

SECRET

USS SKATE (SS305)

3. Increase the strength and protection of main vents and other essential external fittings.
4. Increase strength of securing straps and fittings for external items as mufflers, piping, electric wiring, etc. These items should be faired in as close to the pressure hull as possible and secured to structural members rather than to hull plating.

SECRET

USS SKATE (SS305)

Page 12 of 140 Pages

## TECHNICAL INSPECTION REPORT

### SECTION I - HULL

#### GENERAL SUMMARY OF HULL DAMAGE

##### I. Target Condition After Test.

- (a) Drafts after test; list; general areas of flooding, sources.

Before the test the drafts were 15' - 0" forward and 15' - 7" aft. The ship had a 1/2° list to starboard. Draft readings after the test and before beaching are not available as the Initial Boarding Team was kept away from the ship for reasons of radiological safety. After the vessel was hauled off the beach the readings were 16' - 2" forward and 17' - 9" aft. There was a 2 or 3 degree list to starboard due to flooding of six main ballast tanks and the displacement of damaged structure to starboard. It is believed that one or two of the flooded tanks had been blown during the unbeaching operation.

- (b) Structural damage.

The pressure hull including the conning tower is intact and undamaged except for the port side of frame 55 just above the tank top where 24 inches of the frame welding cracked. This was due to the blast pressure on the conning tower and shears above, and the pressure hull plating is not distorted or damaged. There is no structural damage to compartments. The ballast tanks are intact insofar as structure is concerned, having suffered only minor denting. All damage of consequence is confined to the area above the pressure hull where the superstructure and weather deck are demolished from frame 10 aft to the stern. The conning tower fairwater and bridge are completely demolished. The non-water-tight bow, pivoting at frame 10, appears to have moved to starboard through a very small angle (2 or 3 degrees). The stern above the waterline aft of frame 132 is displaced parallel to the hull axis a distance of 8 inches and crushed in on the port side. The periscope and radar shears are bent about 15° and 25° to starboard.

SECRET

USS SKATE (SS305)

respectively, as a result of failures at the connection to their foundations. A survey of the keel and builders centerline punches in the opt of the frames was made in drydock at the Naval Shipyard Mare Island. The results are plotted in Plate I, page 96. The offsets of the structural hull between the forward perpendicular and frame 103 are not greater than the variations to be expected in building or in making such a survey.

Plate I shows that the stern aft of frame 103 has been bodily bent to starboard through a small angle. In addition, there is an abrupt discontinuity at frame 132 3/4. From this point aft, the free-flooding structure from the top down to the lower shutters has been displaced to starboard. The maximum displacement occurs at the height of the upper shutters and amounts to 4 5/8 inches. The structure above the upper shutters has been rotated slightly in a counter-clockwise direction when viewed from the stern. Photograph on page 80 of Volume II is a stern view which shows this pattern of distortion. The 2 inch diameter stern bar and the 15.3 lb. centerline girder are bent so as to approach the shape of a question mark.

Photographs on pages 81 to 83 of Volume II show the discontinuity at frame 132 3/4. Photographs on pages 84 and 85 of Volume II are closeups of the plating failure at the bottom and top of No. 7 torpedo tube shutter, respectively. Photographs on pages 86 and 87 show the distortion of the 15.3 lb. centerline girder behind No. 8 torpedo tube shutter. The hole in the centerline plate and the local crimping of the vertical stiffeners was caused by the blow from the Tee stiffener on the back of the shutter.

It is considered that the damage to the stern was caused by the blast from the test A bomb striking the port quarter. (Presssures in this location were in the order of 120 lbs./in.<sup>2</sup>). The structure below the waterline was apparently shielded from the direct force. The buckling and collapse of number 8 torpedo tube shutter provided a pocket for the build-up of peak pressures, a phenomenon of frequent occurrence at Bikini.

While the damage did not effect the rudder or diving planes, it was extremely serious in that the entire after tube nest,

SECRET

USS SKATE (SS305)

otherwise almost undamaged, was put completely out of action. All shutters were jammed in the closed or partly closed position.

By referring to Portsmouth plan 89-285, Bureau No. 387260, it can be seen that there are no horizontal longitudinal members between frames 130 and 133. The resistance to side distortion is particularly weak between frame 132 1/2 and 133 where the break occurred. In view of the serious nature of the casualty, it is strongly recommended that horizontal, longitudinal strength members be installed between frames 130 and 133 on all active ships having such construction.

Except for the top of the bow buoyancy tank, the distortion of the bow structure was not so pronounced as that of the stern. Plate I shows the extreme bow at the top to be about 1 7/8 inches to starboard of the ship's centerline. The only structural evidence of this distortion is a compression wrinkle in the top and side plating of the bow buoyancy tank at frame 10.

Although the evidence is not absolutely conclusive, it is believed that the cause of the bow distortion was the blast from test A. However, there is a remote possibility that another ship struck the SKATE's bow during the period of time immediately after test A when the submarine was being towed to the beach.

(c) Other damage.

Both periscopes, the radar masts, bow buoyancy vents, number 7 main ballast tank vent and the main induction valve are inoperable due to the distorted shafting. Nos. 2, 7, 8, 9 and 10 tubes are inoperable due to distorted shutters. Items under cognizance other than 'Hull' were not observed.

SECRET

USS SKATE(SS305)

II. Forces Evidenced and Effects Noted.

(a) Heat.

A heat flash appears to have come from about 220° relative. Some scorched paint remains in protected spots but it appears that scorching was minor and that most of the scorched paint was blown off. The damage to topside light plating is so severe that the remaining evidence of paint scorching is not sufficient to form the basis for any significant conclusions.

(b) Fires and explosions.

There were no fires or explosions.

(c) Shock.

The only evidence of shock is a distortion of the torpedo stowage cradles. This distortion is of such nature as to indicate that the ship (at least the two ends) moved violently and suddenly to starboard. If such motion is assumed, the distortion of the torpedo cradles is probably due to the inertia of the torpedoes stowed in them. No significant amount of shock damage to other equipment throughout the ship was noticed. This fact is remarkable in that war experience with depth charges has inevitably resulted in greater shock damage to other equipment than to torpedo stowage cradles.

SECRET

USS SKATE (SS305)

Page 16 of 140 Pages

(d) Pressure.

The salient force causing damage appears to have been a blast or high velocity wind of relatively long duration, and of such intensity as to apply a high pressure to exposed surfaces parallel to the wave front. This wind demolished all the topside structure and may have caused the displacement of the non-watertight stern structure, but caused no direct damage to the pressure hull. It appears to have come from the port quarter.

The "Coordinator's Report on Air Blast and Water Shock in Tests A and B", dated 27 September indicates, that the peak pressures varied from approximately 120 lbs/in<sup>2</sup> at the stern to 60 lbs/in<sup>2</sup> at the bow and the positive pressure phase had a duration of about 0.42 seconds.

The exposed tank top plating on the port side aft of frame 70 was dished somewhat between frames, apparently as a result of pressure. Between frames 70 and 75 port (in way of No. 5 fuel ballast tank) there is one continuous dent in the plating and frames which has a maximum deflection of six inches. There is no convincing evidence that this dent was caused by the falling of some heavy object. It is therefore assumed to be the result of pressure. The explanation of why this particular area is dished so much more than adjacent similar structure could lie in the fact that between frames 73 and 78 the tank top plating was overhung by a gun sponson which may have locally intensified the pressure by reflecting the wave down onto the tank top. Also, by restricting the flood of air, the gun sponson helped to convert velocity head with pressure head.

(e) Effects peculiar to the atom bomb.

None other than previously described.

SECRET

USS SKATE (SS305)

### III. Effects of damage.

#### (a) Effect on machinery, electrical and ship control.

Except that the bridge and most mooring fittings were blown away, the structural damage had no vital effect on surface operation. After removal of the manhole cover in the top of bow buoyancy the ship could probably have submerged. In this case the main induction would have flooded (via the fracture at the base of the main induction valve and its guide bearing), thus roughly compensating for the weight lost in topside structure. However, at any speed other than dead slow, submerged resistance would have been enormously increased and control of the vessel difficult, if not impossible, due to the unsymmetrical resistance of the damaged structure. The periscopes would have been useless for observation and there would probably have been numerous minor leaks as a result of damaged topside fittings. The effects on propulsion machinery were not observed.

#### (b) Effect on gunnery and fire control.

It may be possible to fire numbers 1, 3, and 5 torpedo tubes. The remaining seven tubes were out of action, for reasons described in paragraph I(c) above and Item D below. Only one gun was mounted and this is damaged beyond use. Had the other guns been mounted they would probably be out of action due to interference from demolished structure if not actually damaged. Fire control is restricted to input from the JK-QC sound gear, as periscopes, radar antennae and TBT's are useless.

#### (c) Effect on watertight integrity and stability.

The watertight integrity of the pressure hull is not affected except for minor leaks due to damaged topside fittings. Main ballast tanks Nos. 2B, 2C, 2D, 6B and 6C flooded slowly to waterline as a result of damaged salvage valves.

SECRET

USS SKATE (SS305)

Page 18 of 140 Pages

Main ballast tank No. 7 flooded as a result of a damaged main vent valve . The total loss of reserve buoyancy was 35%. Within the accuracy of calculation, the metacentric height after flooding is the same as before.

(d) Effect on personnel and habitability.

Aside from radiological casualties (if any) it is estimated that all topside but no interior personnel would have been lost. Habitability within the ship 100% and no noxious gases were detected. (The hydrogen found in the battery compartments is believed to be only the accumulation of four day's normal concentration). Topside habitability is virtually 100% destroyed as far as fighting or operating the ship in a seaway is concerned.

(e) Effect on fighting efficiency.

The one installed gun, seventy percent of the torpedo tubes and almost all means of obtaining fire control data were incapacitated. The ship could not operate submerged (except possibly to a very minor extent) and surface operation in the open sea would be all but impractical. It is therefore estimated that the fighting efficiency was reduced by 90%.

IV. General Summary of Observer's Impressions and Conclusions.

From a hull standpoint, the outstanding feature of Test A is that the pressure hull is not damaged but the non-watertight structure above the waterline (except for the tank tops) is nearly 100% demolished. This is exactly the reverse effect from that a depth charge which attacks only the pressure structure. It is considered that the water provided excellent protection, even for light structure below the waterline, and that, had the submarine been submerged, she would have suffered very little if any damage. However, there can be little doubt that a submarine on the surface would be most effectively put out of action by an atomic bomb explosion such as that of Test A at the ship range prevailing for the test. It is believed that if unmolested, the ship could have

SECRET

USS SKATE(SS305)

proceeded back to port through moderate seas. It is estimated that a good submarine repair yard could restore the ship to her original condition in four weeks or less.

V. Preliminary General or Specific Recommendations of Inspection Group.

(a) Specific recommendations are contained in Detailed Description of Hull Damage. In general it appears that topside structure, fittings, hull openings and personnel must be reduced to an absolute minimum and the unavoidable remainder strengthened and/or protected as much as weight will permit. Such a trend is also desirable from the viewpoint of increasing submerged speed. If submarines depend on surface operation in the open sea much of the top hamper will lose its function and can be automatically eliminated. The rest should be pared to the bone, by drastic redesign of the entire ship if such is necessary.

(b) Atomic warfare introduces the problem of radiological protection and decontamination into ship design. While investigations along this line are not complete, at least part of the solution lies in providing an exposed surface that offers a minimum foothold to radioactive products and one that can be easily given a thorough decontamination treatment.

(c) Experience on the Crossroads Operation indicates that radioactive products are collected by soft porous or rough surfaces and by pockets in the structure. Decontamination processes developed to date consist essentially of removing the radioactive products and the contaminated surface layer (if such exists) by sand blasting, scrubbing, dissolving the surface layer or cleansing it with some material having an affinity for the radioactive particles. Therefore, contamination would be reduced and decontamination facilitated by providing hard, smooth, uninterrupted exterior surfaces with a minimum of pockets and corners.

(d) On submarines, soft; porous; rough surfaces are provided by:

SECRET

USS SKATE (SS305)

1. Wood decks.
2. Bitumastic or paints, especially the thick plastic paints.
3. Rust.
4. Sea growth.

Pockets which collect water and fission products and which are hard to clean out are provided by such structural details as:

1. Tank tops and all other corners or angles in exposed structure.
2. Exposed fittings (valves, piping, mechanisms).
3. Free flooding volumes.
4. Sea chests and circulating water piping.

(e) It therefore appears desirable to make the following changes in submarine design:

1. Eliminate the present type of wood decks.

To a large extent this has been accomplished in the past for other reasons. The substitution of metal for wood should be extended to all locations.

2. Replace bitumastic and plastic paints on all

exposed surfaces with a thin layer of paint or other protective coating having a hard, non-porous surface, resistant to sea growth. If such a covering is not now available a development program should be undertaken.

3. Eliminate sea chests and salt water piping.

Until the development of new types of machinery or cooling systems no constructive comment on this point can be offered.

4. Eliminate free flooding structure. Nearly

all of the free flooding structure of present submarines is found in the superstructure or at the extreme bow and stern. From a practical point of view it appears that some free flooding volume at the extreme ends is inevitable, but that in the superstructure

**SECRET**

**USS SKATE (SS305)**

can be eliminated to a large extent by extending the external tanks, both fuel and ballast, over the top of the hull to form the main deck as was done in late German designs. The increased tank volume thus gained permits tanks to be reduced or eliminated in other locations thus gaining heavy topside plating (as recommended for other reasons in sub-paragraph (a) above) at very little cost in weight. Extending the tanks over the top of the hull requires that topside piping and fittings be drastically reduced, a measure which coincides with other recommendations in this report. Moreover, by providing stiffer topside fairing, one of the chief sources of underwater noise (rattles in the superstructure) will be greatly reduced. Finally, since material such as water or oil, containing light hydrogen atoms, provides the best personnel protection against neutron bombardment, the insulating layer provided in such tanks may be of value in protecting the hull from future atomic weapons.

5. Eliminate pockets and fair out all corners.

The tank top scuppers and many of the pockets now formed by free flooding spaces could be eliminated by extending external tank tops over the hull as described in the preceding paragraph. A large percentage of the remaining pockets and angles could be eliminated by slight changes in the molding lines. This suggestion has the possible disadvantage of increasing cost to build but has the additional advantage of reducing resistance.

6. Eliminate exposed fittings. This is perhaps the most important change recommended not only from a radiological standpoint but also in order to minimize physical damage to material and reduce resistance. Specific recommendations along these lines are contained in the Detailed Description of Hull Damage, particularly under Item K, and will not be repeated here. However, it should be born in mind that almost any fittings provide the irregularities which will collect radioactivity and make decontamination difficult. It must be realized that the retention of exterior fittings or pipe requires justification in the face of the three important considerations dictating removal, namely (1) Reduced hazard to watertight integrity (2) Reduced resistance to propulsion and (3) Reduced severity of radiological contamination and decreased difficulty of decontamination.

SECRET

USS SKATE (SS305)

## DETAILED DESCRIPTION OF HULL DAMAGE

### A. General Description of Hull Damage.

#### (a) Overall condition of vessel.

The pressure hull, including the conning tower, is intact and virtually undamaged. Four main ballast tanks are flooded to the waterline due to slow venting through damaged salvage valves. One other flooded to the waterline by venting through a hole left in the vent riser when 10 lb. blow connection was torn out of the riser. An additional main ballast, number 7, vented through the damaged main vent valve and flooded completely. This main vent valve was forced open three inches by the impingement of the displaced after capstan head. All other tanks are intact. Virtually all superstructure plating and framing, the main deck, and the conning tower fairwater are demolished or missing.

#### (b) General areas of damage.

Nearly all of the hull damage is confined to the area above the pressure hull from frame 10 aft to the stern. The non-watertight bow, pivoting at frame 10, is believed to have moved to starboard through an angle of two or three degrees, causing slight wrinkling of the bow buoyancy tank top and the vertical superstructure plating at frame 10 starboard. The stern aft of frame 132 is displaced parallel to the hull axis a distance of eight inches to starboard. The periscope and radar shears are bent about 15° and 25° respectively, to starboard. All damage was caused by blast from the port quarter.

#### (c) Principal areas of flooding with sources.

Main ballast tanks 2B, 2C, 6B and 6C flooded to the waterline through the normal flood opening, having vented slowly through damaged salvage valves. Main ballast tank 2D flooded to the waterline by venting through the ruptured vent riser. No. 7 main ballast tank flooded completely through the normal

SECRET

USS SKATE (SS305)

flood openings, having vented through the main vent valve which was forced open 3 inches by the displaced after capstan head. There is no other flooding.

- (d) Residual strength, buoyancy and affect of general condition of hull on operability.

The residual strength has not been impaired except negligibly in that the after edge of frame 55 has pulled away from the hull for a length of 24 inches just above the port tank top. The remaining residual buoyancy is 67%. Within the accuracy of calculation, the flooding of the main ballast tanks did not change the metacentric height. The hull damage does not prevent surface operation. Although the pressure body appears to be pressure tight, the ship could not have dived immediately after the test because the bow buoyancy vent was jammed in the closed position. The demolished superstructure would make submerged control at moderate and high speeds extremely difficult.

#### B. Superstructure.

- (a) Description of damage.

Except for a very small section just aft of the conning tower fairwater and the area forward of frame 15, the main deck is entirely demolished. The vertical superstructure plating on the port side from the stern to frame 15 is demolished and/or missing. The starboard vertical plating is distorted but in place except for a missing section from frame 53 to 62. With the following exceptions superstructure bulkheads and frames are torn loose near or at their attachment to the hull and are demolished or missing. The bulkhead at frame 10 is only slightly distorted. The port side of the swash bulkhead at frame 32 is torn loose and folded forward. The starboard half is in place although badly distorted. Nearly all small fittings projecting above the pressure hull and about 50% of the small topside piping have been carried away or damaged by or with the demolishing of the superstructure. Photographs on pages 4 and 5 of Volume II show the damaged superstructure and main deck as seen from the top

SECRET

USS SKATE (SS305)

of the conning tower, and photographs on pages 6 and 7 of Volume II show the damaged areas as seen from the bow and stern respectively.

The conning tower fairwater and the deck at the bridge level were completely demolished and blasted forward onto the forward 40mm gun. The STS wing bulwarks were blown out and folded forward swinging through 180°. The shaped STS shield forward of the bridge was blown forward over the 40mm gun. See photograph on page 8 of Volume II which shows the bridge shielding as seen from the conning tower, looking forward, and photograph on page 9 of Volume II which was taken from forward of the conning tower, looking aft. The resultant distortion in the 20# STS caused some fractures through this plating but in most cases failures were in the 25-20 austenitic welds. In virtually all cases where the galvanized mild steel conning tower fairwater plating was welded to STS with 25-20 electrodes the bond between the mild steel and the weld metal failed.

All damage appears to have been caused by air blast.

(b) Evidence of fire.

There is no evidence of fire. Most paint that was scorched seems to have been blown off, leaving bare metal over a large part of the exposed surfaces.

(c) Estimate of relative effectiveness against heat and pressure.

The topside plating varies from five pound galvanized mild steel to 20 pound STS and presented all angles of attack. None of the plating exhibited any resistance worthy of note. It should be remembered that nearly all of it is tied together and the structure as a whole was blasted away. Both 20# and 40# STS ready service lockers are undamaged, although torn from their foundations. This is probably due to their heavy scantlings on a small diameter, rather than to the STS.

SECRET

USS SKATE (SS305)

(d) Constructive criticism of superstructure.

To reduce the damage caused by such an attack it appears desirable to reduce the light structure topside to a minimum, and to increase the thickness of the remainder to about 15# plate as well as secure it to the pressure hull with stronger connections. It might be desirable to install all necessary superstructure in relatively small unconnected sections to prevent the apparent "peeling off" that occurred on the SKATE. Each displaced piece of superstructure becomes a hazard to other equipment. Protective plating around the bridge (in this case STS) should be welded to the pressure hull rather than to other light structure.

C. Guns and Directors.

(a) Guns.

There are no directors. The forward 40mm gun was the only installed gun at the time of the test. This gun is completely misaligned, probably as a result of the conning tower fairwater being blown onto it. See photograph on page 9 of Volume II. The forward 40mm gun foundation is undamaged. The after 40mm foundation was destroyed when the "cigarette deck" was torn off. Both 5" gun foundations are undamaged except that on the forward foundation the strengthening bracket on frame 42 port is slightly buckled. This may be a result of being hit by other structure, aggravated by the fact that the toe of the bracket was never welded to the top of the hull frame. No working platform for any gun remains.

(b) Target bearing transmitter foundations.

The after target bearing transmitter and its foundation completely carried away with the bridge structure. The forward target bearing transmitter was carried forward with the bridge shelf, but the instrument does not appear to be seriously damaged.

SECRET

USS SKATE (SS305)

(c) Periscope foundations.

The periscope foundations are not damaged except for some cracked welds where the plating was welded to the conning tower plating. The shears are intact except that the heavy figure eight flange at the bottom of the shears has an offset of about 1/2 inch across its narrow section. Also the welding between the foot of the shears and the figure eight flange plate is cracked for about 12 inches. The bolted joint between the foundation and the shears failed, permitting the shears to be pushed to starboard to an angle of about 15°. This, of course, bent the periscope tubes. The failure was in the studs and bolts, about 50% of which failed in tension and the remainder in bending or in stripping of the male threads. See photograph on page 10 of Volume II. The periscopes have not been removed for examination.

(d) Radar mast foundations.

The foundation for the SD radar mast was distorted. The port 6 x 6 "H" beam leading down and aft to the hull is buckled in a smooth curve forward and to starboard, with maximum deflection of 3 inches about mid length. The upper end of this beam has been badly punctured and distorted by contact with adjacent structure. The toe bracket on the inboard side of the port beam at the hull shows an unstable compression failure. The starboard "H" beam shows an unstable compression failure in the region 2 - 8 inches above the hull. The deformation in the port leg is apparent due to being hit by other structure, whereas the starboard leg failed due to the blast pushing the after end of the upper part of the foundation to starboard. The angle forming the horizontal strut between the two legs is parted from the starboard leg at the weld. The upper part of the radar mast foundation consists of a 20 pound plate in the shape of a rectangular box with a vertical axis. The after end of this box was hit by the antenna trunk and moved to starboard about 4 inches, distorting the geometry. The radar mast shears is undamaged except that it failed at its base just above the weld between the plating and the lower flange. The failure extended for about 80% of the

SECRET

USS SKATE (SS305)

perimeter of the base of the shears. This failure permitted the mast and shears to be blown over to starboard at an angle of about  $25^{\circ}$ . See photograph on page 11 of volume II. The radar mast has not been removed for examination.

(e) Constructive criticism.

If guns and TBT's are to be installed on submarines in the future their foundations must be secured to the hull (as are the present 5" foundations) and a working platform which is sturdy, secured to the pressure hull, and independent of the remainder of the superstructure must be provided.

The most basic and effective improvement that could be made in the periscope and radar mast supports is to reduce the length of the periscopes and radar masts, and thus reduce the height of their supports. This reduction in length can be attained by providing better submerged control near the surface, a characteristic which can be improved to a large extent by improving the dynamic characteristics of the hull. The suggestion made by the commanding officer of the PILOTFISH to install telescopic shears is considered to provide a possible source of improvement, but which introduces undue complications without compensatory benefits. The extensible bearings used experimentally by the German submarines in the last war (essentially the same principle) were often a source of trouble and were only slightly successful in reducing periscope vibrations,

D. Torpedo Mounts, Depth Charge Gear.

(a) Tubes.

The muzzle ends of all torpedo tubes were bent, the stern tubes to a greater degree than the bow. The distance from the muzzle at which the bore gage jammed is shown in the last column of Plate II on page 97. The axes at the muzzle ends of the stern tubes were displaced inboard and up (as compared with the centerline of the straight section of the tube) by the following amounts:

<u>Tube No.</u>	<u>Inboard(inches)</u>	<u>Up (Inches)</u>
7	1/32	1/16
8	1/2	1/16
9	1/16	1/16
10	0	1/32

SECRET

USS SKATE(SS305)

Page 28 of 140 Pages

The bow tubes were bent to starboard to a somewhat lesser degree but this particular measurement was not taken.

The muzzle doors on all stern tubes were sprung by the distortion of the shutters, but except for the tube number 8 they returned to their approximate normal position after the shutters were cut away. On tube number 8 the muzzle door hinges arms were permanently deformed so that the door was displaced about half the width of the seat to starboard.

As a check on the hull distortion all torpedo tubes were boresighted and the centerline of each tube nest was compared with the centerline of the keel as determined from the structural survey. Only the straight portion of each tube was used for determining the tube centerline. There was no evidence of individual displacement of any one tube relative to the remainder of the tube nest. The position of the tube nest centerline is in essential agreement with the hull survey. The centerlines of the tube nests forward and aft have been plotted on Plate I for purposes of comparison. When viewing Plate I note that the athwartships scale is 96 times the longitudinal and therefore all angles are magnified by this factor.

Except for those tubes where the shutters had to be cut out, the results of a check on the torpedo tube muzzle door and shutter clearances are shown on Plate II. They show evidence of slight distortions and jamming. The distortions of the shutters on tubes 2, 7, 8, 9 and 10, or those of the adjacent structure, were so severe as to prevent opening the muzzle doors.

Shutter number 2 was dished in at midlength a distance of about 5 inches as shown in photographs on pages 88 and 89 of Volume II.

Shutter number 7 was bent inboard at the top a distance of about 2 inches and the upper guide plate was displaced outboard about 6 inches. The top roller had indented the inboard side of the track about  $1/8''$  and then the roller shaft sheared off at the lower face of the roller. See photographs on pages 80 to 82 of Volume II. The distortion of the lower edge of this shutter can be seen in photograph on page 90 of Volume II.

SECRET

USS SKATE (SS305)

Shutter number 8 was the most severely damaged. It crumpled in at midlength, striking the centerline bulkhead with great force. The forward end was held approximately in position by the muzzle door. At the after end, the top roller came out of the track. The lower roller assembly stayed approximately in position but was badly bent. Photograph on page 91 of Volume II shows the general distortion. The inboard side of the upper track was indented about  $1\frac{1}{4}$ " as can be seen in photograph on pages 92 and 93 of Volume II, and the inboard side of the lower track was completely opened up. The upper guide plate has been forced down about 4 inches at the outboard edge and the lower guide plate has come up slightly above the normal position at the outboard edge.

The shutter for number 9 torpedo tube is only slightly distorted. A shallow impression from the roller is apparent in the inboard side of the lower track. The after end of the shutter has opened somewhat away from the shell plating. Photograph on page 80 of Volume II shows this opening.

The top after edge of number 10 shutter was forced in about 3 inches and the guide plate had drooped about 1 inch in this same area. This distortion effectively jammed the shutter which had no other significant damage.

Torpedo shutter clearances were taken wherever possible and are shown on Plate II on page 97.

(b) Cradles and loading gear.

The torpedo stowage cradles give evidence that both ends of the ship moved suddenly and violently to starboard and upward, particularly the stern. One side plate of almost every cradle is sprung out, particularly the length from the end nearest the war head back to the first thwartships track roller. In all cases this distorted side plate is the one on the side of the cradle which is nearest the port side of the ship. All cradle locking pins, except those in the after end of the forward cradles, are bent and jammed. In several cases, the cradle track roller nearest to the warhead, and on the same side as the distorted side plate, is above the plane of the other three rollers. One

SECRET

USS SKATE (SS205)

after strap in the forward room is broken. It is considered that when the ends of the ship moved suddenly to starboard, the inertia of the torpedoes forced them against the side of the cradle. The heads of the torpedoes, being heavy and overhanging the supporting tracks, pushed especially hard against the sides of the cradles. In way of the rollers the stringing out of the side plate was prevented by the fact that the roller bore against the track. Therefore, there is an apparent bulge inward of the side plate in way of the roller housing. See photograph on page 12 of Volume II.

A check of all tracks in drydock showed that the average discrepancy from the plan dimension is less than  $1/8''$  which is within the usual builders tolerance. The maximum difference was  $3/16''$  low on the forward track of number one tube. No difficulty in unloading torpedoes was encountered except in starting the torpedoes out of No. 3 tube. This was probably due to a rusty torpedo and possible high spots in the tube barrel.

(c) Air flasks and war heads.

The number 2, 4 and 6 torpedo tube air flasks in the superstructure were struck by the side of the superstructure when it was demolished. The air flasks themselves do not appear damaged but were displaced. On number 6 tube the displacement was about 8 inches and the pipe of the hull fitting tore out of its upper screwed flange. On number 2 tube the displacement was about 3 inches causing severe distortion but no visually noticeable failure of the lead in piping.

(d) Constructive criticism of location, design and construction.

If torpedo air flasks continue to be located outside the hull they must be secured to the pressure hull by stronger straps. Also they should be shielded as much as possible.

SECRET

USS SKATE (SS305)

E. Weather Deck (Fl. Dk).

Combined with Item B.

F. Exterior Hull.

(a) Condition and causes of damage.

The pressure hull plating is undamaged. With the following minor exceptions, the pressure hull framing is undamaged.

1. Frame 55 port. The welding at the after end of the lower face plate failed from the tank top toward the center for a distance of about 24 inches. This was apparently due to the stress set up in the conning tower foundations when the blast hit the structure above. See photograph on page 13 of Volume II.

2. A heavy object struck the top flange of the 6 x 6 "H" beam at frame 47, producing a dent about 6 inches long, 3 feet above the tank top. Frame 49 is dented in a similar manner to frame 47.

3. The top flanges of frames 113 and 114 at the top of the hull are canted slightly down on the forward edge (about 1/2 inch). The hull plating in the vicinity is not dished nor do any frames show similar distortion. It is possible that they were canted before the test.

4. Long base displacement gages mounted in the torpedo room show the following elastic deflections in inches and their directions. They do not exceed those experienced at deep submergence:

	Fwd.	Aft
Horizontal Axis	0.180 in	0.060 in
Vertical Axis	0.070 out	0.200 out

SECRET

USS SKATE (SS305)

Bow framing is intact and undamaged.

The stern framing is intact forward of frame 132. There is a sharp discontinuity between frames 132 and 133, marked by severe wrinkling of the plating. The section of the non-watertight hull aft of frame 133 is displaced upward and to starboard about 4 inches. The top half has also rotated slightly so that the starboard side is higher than the port. The transverse frames on the starboard side are bent in near the waterline. The number 8 torpedo tube shutter has been pushed in against the centerline plate girder and severely crumpled. This bent the plate girder to port about 2 inches at midheight. The top after corner of the No. 7 shutter was pushed in against the centerline girder. There is no evidence of any object striking this stern structure and no cause for the damage other than bomb is known. See photographs on pages 14, 15, 16 and 17 of Volume II.

Except as mentioned previously no hull welding failures were observed. No failures of structural castings were noted. The bolts in the flanged joint between the antenna trunk hull casting and the first section of trunk failed, permitting the trunk to be layed over to starboard. See photograph on page 18 of Volume II.

(b) Constructive criticism of design or construction.

It appears that the structural members of the pressure hull are of adequate design to resist this type of attack. The continuity of the stern longitudinal framing should be improved with a view to preventing the type of damage which occurred aft of frame 132. See the remarks in paragraph I (b) of section I. Such damage is of extreme gravity for it incapacitates otherwise intact torpedo tubes.

SECRET

USS SKATE (SS305)

G. Interior Compartments (above w.l.)

(a) Damage to shell, bulkheads and framing and causes.

There is no damage to the interior shell, bulkheads or framing.

(b) Damage to joinder bulkheads, decks, and floorplates and causes.

There is no damage of any consequence to joinder bulkheads, decks or floor plates.

(c) Damage to access closure and cause.

All watertight hatches and doors are undamaged.

(d) Damage to hull fittings and equipment and causes.

No damage to hull fittings and equipment was noted.

(e) Damage to foundations, shock mounts and sound mounts and causes, including battery tanks.

No interior foundations are known to have failed. The QLA sound stack in the forward torpedo room was mounted on No. 90 Lord Mfg. Co. mounts, four below and two sway mounts at the top. At the bottom, the after starboard mount pulled loose from the deck socket and at the top both mounts pulled away from the supporting bracket. As a result the QLA sound stack was adrift. However, the ship's force stated that the top sway mountings were not secured to the foundation bracket previous to this test. Therefore, the failure has but little significance.

In the forward battery tank the inboard ends of several of the tie rods which hold the row of cells second from outboard on the starboard side tended to pull through the insulation angle bar which supports this row of cells. In one instance (about mid length of the tank) the nut had snapped off. See photograph on page 19 of Volume II.

SECRET

USS SKATE (SS305)

(f) Evidences of fire.

There is no evidence of fire.

(g) Damage to watertight integrity and causes.

The following instances of reductions in watertight integrity of the hull were noted:

1. The topside operated switch for the after capstan (frame 109) was carried away with part of its shaft, leaving a 3/8 inch hole through the stuffing box.

2. The flapper valve on the lower end of the antenna trunk had jarred off its latch, and was found in the open position (See Portsmouth Plan 1536-285, BuShips No. 490253M). As the ship was not submerged, no large amount of water entered here, but this design does not provide positive and adequate locking in the closed position. Although the flapper closes with sea pressure, a piece of the porcelain dam or other foreign material might easily jam a flapper which had been jarred open.

3. Damage to numerous topside fittings resulted in loss of the outboard closure stage of the double protection feature incorporated in most fittings. An example of this is the leaking muzzle doors on torpedo tubes 7 and 8.

4. Fifteen pound compartment air test, made before Test A and after minor non-structural repairs subsequent to Test A resulted in the following drops in the times indicated.

<u>Compartment</u>	<u>Before Test A (in 15 min.)</u>	<u>After Test A (in 12 min.)</u>
Fwd. Torp. Rm.	0 oz.	No final test.
Fwd. Batt. Compt.	4 oz.	3 oz.
Cont. Rm. and Con. Tow.	4 oz.	5 oz.
After Batt. Compt.	0 oz.	5 oz.
Fwd. Eng. Room	8 oz.	3 oz.
After Eng. Room	0 oz.	4 oz.
Maneuvering Room	5 oz.	3 oz.
After Torp. Room	2 oz.	6 oz.

SECRET

USS SKATE (SS305)

Page 35 of 140 Pages

(i) Constructive criticism as to design or construction.

Shafts, cables and pipes leading through the hull jeopardize the watertight integrity of a pressure hull which is otherwise adequate to resist such an attack. They should be ruthlessly reduced to the absolute minimum, and the unavoidable remainder heavily protected. Such items as the exterior after capstan switch are unacceptable.

The flapper latch on the lower end of the antenna trunk, described in paragraph (g) (2) above, is inadequate. It is understood that the design has been improved. It should permit no possibility of the subject casualty.

H. Armor Decks.

None fitted.

I. Interior Compartments (below w.l.).

Combined with Item G.

J. Underwater Hull.

A divers examination revealed no damage to the underwater body. Shafts, stern planes, rudder and bow planes all operate satisfactorily.

K. Tanks.

(a) Condition and causes of damage.

Examination in drydock and air tests of representative tanks disclosed no significant damage. Along the top of the port wing tanks from frame 80 aft there are some small dents between frames, apparently caused

SECRET

USS SKATE (SS305)

by the pressure wave. There is also one large dent (about 6 inches deep in the center) in the tank top between frames 75 and 80. See photograph on page 20 of Volume II. This could have been caused by the impact of some heavy object but there are no scars in the plating severe enough to substantiate this theory. A gun sponson overhangs the tank top between frames 73 and 78. It is possible that this sponson reflected the pressure wave down onto the tank top with a resultant local increase in pressure. The port side of the after bulkhead of the bow buoyancy tank, is dished about 2 inches forward and the welding at the lower port **cover** is torn for a distance of 8 inches.

(b) Leakage and causes for all tanks.

Main ballast tanks 2B, 2C, 6B and 6C are flooded to the waterline due to slow venting through damaged salvage valves. (See machinery report on salvage valves). Main ballast tank 2D is flooded to the waterline due to venting through a hole where the 10 lb. blow line pulled out of the vent riser. Number 7 main ballast tank is completely opened because the linkage and seat were distorted by the after capstan head which bent over to starboard by the blast. See photographs on pages 21, 22 and 23 of Volume II.

(c) Flood valves and linkage.

All flood valves and linkage operate satisfactorily and appear to be undamaged.

(d) Flood valves hand operating gear.

The hand operating gear on all flood valves is undamaged.

(e) Vent piping.

Several main ballast tank vent risers are dented and partially crushed due to being struck by other structure. On main ballast tank No. 2D the 10 pound blow line pulled out of the

SECRET

USS SKATE (SS305)

vent riser leaving an oval hole 2" x 4". Except for main ballast tank 2D all risers are airtight.

(f) Main and emergency vent valves.

The linkage for the bow buoyancy vent valves is severely distorted from frame 26 forward to frame 18 by the crushed superstructure. The valves are closed tightly but cannot be opened due to the distorted linkage. The inboard vents on fuel ballast tanks 3A and 5A and B are broken off at the main vent valve housing. As described above (paragraph K (b) ), the No. 7 main ballast tank vent valve was damaged by the after capstan head. The valve seat is dented about 1/2 inch on the inboard side and the flapper hinge is pushed down about 1/2 inch on the inboard end. The screens on several other main vent valves are distorted and punctured but all main vents other than those specifically mentioned above are undamaged. All emergency vent valves operate satisfactorily.

(g) Constructive criticism and recommendations.

1. The main ballast tank salvage valves are extremely susceptible to damage in this type of attack. The valve itself cannot be depended upon to be tight even if undamaged. Therefore, in the past, reliance has been placed on the cap at the end of the riser. In nearly all cases on the SKATE, including the compartment salvage connections, the riser or the cap was broken off. While a leaking salvage valve does not constitute a serious hazard to the submarine, it would appear desirable and feasible to remove all salvage connections during war patrols.

2. Wherever practicable heavy objects which are subject to distortion, such as the after capstan, should not be located near a main vent valve. It might be feasible to build a strong protective shield around the main vents, in a manner similar to the present screens, in order to prevent jamming or damage from other displaced structure.

SECRET

USS SKATE (SS305)

3. The bow buoyancy vent valve linkage has been a hazard throughout the past war due to its long length and vulnerability. While the crowding in the forward end of the torpedo room in the present design of submarines is fully appreciated, a solution to eliminate the long run of linkage appears to be mandatory in new design.

4. Small exterior lines such as inboard vents for fuel ballast tanks should be given protection or positive support, especially support adjacent to the valve housing and adjacent to the hull.

5. The 10 lb. blow lines, which were torn in numerous locations (see machinery report) constitute a serious hazard to ballast tank integrity. If the 10 lb. blow system is not eliminated entirely, the proposal of the commanding officer to locate the lines within the pressure hull merits careful consideration despite its undesirable aspects.

6. A significant number of exterior fittings (such as vent valves, flood valves, vent risers, 10 lb. blow lines and valves) can be eliminated by abandoning fuel ballast tanks. Except in submarines that are expected to spend a high percentage of time on the surface (an unlikely prospect for future war patrols) the primary function of these tanks has disappeared. For example, late German submarines had no fuel ballast tanks. There are other reasons for eliminating these tanks, such as reduced cost, space required and weight, and simplified design, but one of the most important reasons is that this would permit the elimination of topside fittings which are now vulnerable spots and which require increased superstructure volume.

#### L. Flooding.

There is no flooding except in those tanks discussed under Item K. All tanks except main ballast tanks Nos. 2D and 7 flooded slowly, and adequate temporary repairs to these tanks could have been made by the crew if a few hours on the

SECRET

USS SKATE (SS305)

surface were available. However, as stated under Item K above, the possibilities of using the salvage valves in war time does not appear to justify the hazard they create.

M. Ventilation.

(a) Condition and causes of damage.

1. The main induction valve with attached piping was pushed 10 inches to starboard. This resulted in the bending of the induction piping in this direction. Tightness of the main induction valve proper was not affected by the damage. However, the purpose of the valve was nullified by fracture of the lower reduced section of the casing which connects the valve body to the pressure hull. Bending of the disc guide rods over the disc and the bending of the valve stem at the hull made it impossible to operate the valve. The outer casing of the valve body is wrinkled at the after and port side and a small tear of about 2 inches was found on the port side. Angle bar supports of the valve are bent and torn loose. See photographs on pages 24, 25, 26, and 27 of Volume II.

2. The forward engine induction piping on the port side is slightly flattened at the elbow connection to the valve as a result of bending. It is also raised 24 inches and pushed 30 inches inboard between frame 50 and the hull valve. This bending inboard caused a distortion of the after portion of the pipe flange connection to the hull induction valve housing and a bending of the flange bolts which is sufficient to permit leakage. Practically all of the pipe supports were torn loose at the weld to the hull. See photographs on pages 20 and 28 of Volume II.

3. The hull ventilation supply line was pulled 10 inches to starboard near the main induction valve. However, the piping did not rupture. The line was also lifted about 6 inches between frames 65 and 70 and supports torn from hull in this area.

SECRET

USS SKATE (SS305)

4. The forward section of the after engine and maneuvering room air induction piping was pushed outboard with the main induction valve. It was also pushed outboard two inches at about frame 101. Supports in way of the pipe section near the main induction valve and at frame 101 were torn loose from the hull.

5. No welded joints in any of the induction piping failed nor did the strap type supports cause any damage to the pipe itself.

6. There is no damage to the inboard hull ventilation system. Battery ventilation is intact except for a short section of the individual cell ventilation duct between cells 1 and 2 in the forward battery. This section was shattered. See photograph on page 29 of Volume II.

(b) Evidences that ventilation system conducted heat, blast, fire, smoke or water into any compartment.

There is no evidence that ventilation piping carried smoke, fire or water into any compartment.

(c) Constructive criticism of design or construction.

To resist atomic bomb attack on the surface the weld between the foot of the induction piping supports and the hull must be stronger. Also pendant structures (such as the main induction valve), which are unavoidable, must be extremely well braced. However, it appears that a major redesign is in order, placing more emphasis on locating the main induction and the engine rooms closer together. Ideally, there should be no exterior induction piping.

#### N. Ship Control.

(a) The bridge is eliminated due to failure of the structure as described under Item B. There is no damage to the structural boundaries of the conning tower or the control room.

SECRET

USS SKATE (SS305)

O. Fire Control.

Combined with Item N.

P. Ammunition Behavior.

(a) Condition and causes of damage.

1. Ready service stowage.

No ammunition is damaged. Two 40mm ready service lockers are missing. Although the remainder of the ready service lockers were blown about, there is no damage to the shell of any locker. It is impossible to open the forward 40mm ready service due to distortion of the locking device caused by the impact of other structure.

2. Magazines.

The ship's magazines are undamaged.

3. Constructive criticism.

The only suggestion that can be made for improvement of the present design is to support the ready service lockers more securely, preferably attaching them to the pressure hull.

Q. Ammunition Handling.

(a) Condition and causes of damage.

The outer door of the 5" ammunition passing scuttle at frame 67 was unlocked when examined. The door is locked by a rotating ring which can be actuated from topside by turning a "T" handle. It is possible that moving structure hit this handle and unlocked the door. No other cause is known or considered feasible. There is no damage to the scuttle.

SECRET

USS SKATE (SS305)

4. The forward section of the after engine and maneuvering room air induction piping was pushed outboard with the main induction valve. It was also pushed outboard two inches at about frame 101. Supports in way of the pipe section near the main induction valve and at frame 101 were torn loose from the hull.

5. No welded joints in any of the induction piping failed nor did the strap type supports cause any damage to the pipe itself.

6. There is no damage to the inboard hull ventilation system. Battery ventilation is intact except for a short section of the individual cell ventilation duct between cells 1 and 2 in the forward battery. This section was shattered. See photograph on page 29 of Volume II.

- (b) Evidences that ventilation system conducted heat, blast, fire, smoke or water into any compartment.

There is no evidence that ventilation piping carried smoke, fire or water into any compartment.

- (c) Constructive criticism of design or construction.

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SECRET

USS SKATE (SS305)

For damage to torpedo stowage cradles see Item D (b).

In the after torpedo room, the portable center section for the after athwartships tracks is normally stowed in clips on the side of the port upper track. See photograph on page 30 of Volume II. Upon entering the room, the portable section (which is essentially a steel bar about 24 x 3 x 1-1/2 inches) was found lying beside the war head of the torpedo in the lower starboard cradle, and there was a triangular puncture through the war head casing which matched the corner of the portable track section. The puncture was approximately one inch long on each of its three sides. See photograph on page 31 of Volume II.

(.) Constructive criticism.

It is recommended that more emphasis be placed on eliminating the "missile hazard" by installing better stowages for loose items.

R. Strength.

There is no apparent damage to the ship's structural strength except to a negligible amount where the welding failed for a short distance on frame 55 (see Item F, paragraph (a), (1)).

S. Miscellaneous.

No comment.

T. Welding and Rivetting.

In general, the mild steel welding gave performance compatible with its design. The failure at frame 55 is the only notable exception. In welds joining mild steel to STS, where austenitic welding electrodes were employed, the weld beads pulled away from the mild steel in numerous instances. Also the butts

SECRET

USS SKATE (SS305)

in the STS splinder protection failed frequently in the weld. See photograph on page 32 of Volume II.

The most apparent deficiency noted was the poor performance, under the severe blast conditions imposed, of socket joints in salt water lines which were fabricated using low temperature brazing alloy. The failures observed indicated that both faulty workmanship and brittle brazing materials were responsible for a considerable amount of the damage sustained by these lines. Faulty workmanship was evidenced by the lack of penetration of the brazing alloy into the joints, and by a lack of sufficient bonding of the brazing alloy to the surfaces of the joints. The latter condition indicates either improper cleaning of the joint surfaces before brazing or improper fluxing. The brazing alloy used in making the joints is suspected of having poor ductility and low resistance to shock because of the brittle nature of sample chips removed from the joint with a chisel. Identification of this material will be attempted through an analysis of the samples taken.

In sharp contrast to the performance of brazed joints, welded joints in steel castings, vents and induction lines withstood the shock of the blast satisfactorily. One butt weld observed in a copper nickel alloy salt water line underwent considerable deformation without failing.

Bronze outboard exhaust valves fabricated by welding sustained limited deformation without failing. However, in one instance failure took place in a porous bronze arc weld joining a cooling water line fitting to the waterjacket of the exhaust elbow. See photographs on pages 33 and 34 of Volume II.

While it is generally true that welds on the SKATE performed satisfactorily it will be noted that in the stern of the main induction valve casing, failures took place adjacent to the welds. It is considered that a reduction of abrupt discontinuities, affected by the blending of sections and members at connections and intersections would materially reduce failures of the type shown in the photograph on page 35 of Volume II.

SECRET

USS SKATE (SS305)

Recommendations. As a result of the findings set forth above, the following recommendations are made:

1. Consideration be given to conducting an examination of the low temperature brazed joints now installed on a representative group of inactive submarines to determine the quality of such joints with regard to workmanship. It is suggested that the examination include sectioning of joints and inspection of the sections for penetration and bonding of the brazing alloy.

2. Tests be conducted at a naval laboratory to determine the relative shock resistance of the low temperature brazing alloys approved for use by the navy. It is suggested that the investigation include tests on actual brazed pipe joints of representative types and size.

3. That consideration be given to changes in the design of members in way of connections, intersections and changes in section in effort to reduce, wherever practical, by blending, abrupt discontinuities at locations subject to shock loading.

#### U. Coverings.

(a) To a large extent the exposed paint on the superstructure is missing and is assumed to have been blown off. There is little evidence of scorching but there is virtually no paint left on surfaces which faced the blast; therefore the apparent lack of scorching may be misleading. Exterior paint on the pressure hull and interior paint appears undamaged.

(b) The galvanizing shows no evidence of damage other than local gouging where it was struck by displaced structure.

(c) As recommended in paragraph V of the General Summary of Hull Damage, coverings should be investigated with a view to provide materials more suitable from a radiological standpoint.

SECRET

USS SKATE (SS305)

## TECHNICAL INSPECTION REPORT

### SECTION II - MACHINERY

#### GENERAL SUMMARY OF MACHINERY DAMAGE

##### I. Target Condition After Test.

- (a) Drafts after test; list; general areas of flooding, sources.

Draft immediately after test was less than a foot increase by the stern caused by flooding of number 7 main ballast tank due to jamming open of No. 7 main vent by displaced after capstan. List was 2 or 3 degrees to starboard due to bent periscope sheers and radar mast. Main ballast tanks 2B, 2C, 2D, 6B and 6C were flooding slowly as a result of damaged and slow leaking external salvage air fittings. Since the ship was fairly high in radioactivity and therefore could not be boarded for repair of leaking salvage fittings, she was beached on the day of the test to prevent possible sinking.

- (b) Structural damage.

Structural damage was confined to the topside superstructure and external fittings. Pressure hull and all hatches were tight. This item covered in detail in hull report.

- (c) Other damage.

All ship control and propulsion machinery inside the pressure hull was undamaged, was tested and was operable.

##### II. Forces Evidenced and Effects Noted.

- (a) Heat.

The only effect noted of heat was slight scorching of paint on upper portion of periscope sheers on side toward burst.

SECRET

USS SKATE (SS305)

(b) Fires and explosions.

No evidence of fires nor explosions aboard this vessel were noted.

(c) Shock.

Mountings of QLA sound stack in forward torpedo room and TBL transmitter in radio room failed. These failures could have been due to extreme rolls of vessel. The only pure shock effects noted by this observer were failure of upper support bearing of sound stack after bearing repeater in conning tower, clocks lens in after engine room, shattered hard rubber battery ventilation duct section in forward battery tank, shattered light bulbs, and after gyro setting regulator motor jarred from its supporting flange. See photographs on pages 29, 36, 37, 38, 39, and 40 of Volume II.

(d) Pressure.

A great blast pressure force was evidenced from the direction of the bomb burst in the ripping and tearing off of all the superstructure deck and the damage to most of the fittings outside the pressure hull. See photograph on page 41 of Volume II.

(e) Any effects peculiar to the atom bomb.

Effects noted peculiar to the atom bomb were radioactivity and extreme blast.

### III. Effects of Damage.

(a) Effect on machinery and ship control.

Negligible. The bridge was destroyed but ship could be and was conned. Propulsion not affected.

(b) Effect on gunnery and fire control.

Topside guns destroyed, loss of about 50% volume of torpedo fire due to structural damage to torpedo tubes.

SECRET

USS SKATE (SS305)

Topside torpedo control equipment destroyed (periscopes, TBT's, radar, topside sonar). Internal torpedo control equipment undamaged except for power setting of after gyros lost due to motor being knocked off.

(c) Effect on watertight integrity and stability.

Not damaged beyond capacity of ship to control.

(d) Effect on personnel and habitability.

Disregarding possible radioactive effect, it is believed personnel inside pressure hull would have been unaffected. Habitability inside pressure hull not impaired. Personnel topside would probably have been killed.

(e) Total effect on fighting efficiency.

Reduced to less than 25% due to damage to fire control equipment topside and to guns and torpedo tubes.

IV. General Summary of Observers' Impressions and Conclusions.

The SKATE as a living ship was essentially intact. Her fighting efficiency was almost totally destroyed but she could have lived to fight again. It is believed that no damage whatsoever would be sustained by a submarine submerged to periscope or greater depth by an air burst of an atomic bomb.

V. Any Preliminary Recommendations.

If submarines are to be capable of withstanding on the surface a near air burst of an atomic bomb, it is recommended that the following items be accomplished:

1. Reduce surface silhouette by reducing height of periscope and radar mast supports and full length superstructure. Wood deck should be entirely eliminated and plating

SECRET

USS SKATE (SS305)

above pressure hull should be faired, rounded, fairly heavy and only high enough above pressure hull to enclose absolutely essential external fittings.

2. Eliminate as many as possible of pressure hull openings and external hull fittings including salvage fittings.

3. Increase the strength and protection of main vents and other essential external fittings.

4. Run main induction piping inside pressure hull.

5. Interchange after engine room and after battery compartment thereby reducing run of engine induction piping.

6. Increase strength of securing straps and fittings for external items such as mufflers, piping, etc.

**SECRET**

**USS SKATE (SS305)**

Page 49 of 140 Pages

## DETAILED DESCRIPTION OF MACHINERY DAMAGE

### A. General Description of Damage.

#### (a) Overall condition.

All machinery and piping within the pressure hull is intact and undamaged. The following items and pipe lines were damaged outside of the pressure hull:

1. Torpedo impulse piping forward.
2. Salvage piping and fittings.
3. 10 p.s.i. blow piping.
4. #2, #4 and auxiliary diesel mufflers.
5. #2 and #4 outboard exhaust valve and external piping.
6. Periscope and radar mast hydraulic hoist piping ruptured.
7. Fuel oil compensating piping.
8. QB sound head shaft bent (due to beaching).
9. After capstan shaft bent and inoperable.
10. Submerged signal ejector barrel torn off. (Control room ejector.)
11. No. 7 main vent damaged.
12. Bow buoyancy vent mechanism damaged.
13. Both periscopes and both radar masts bent and inoperable.

SECRET

USS SKATE (SS305)

Page 50 of 140 Pages

14. QLA sound head shaft (topside) bent.

15. JP sound head and shaft above hull flange ripped off. See photograph on page 42 of Volume II.

(b) Areas of major damage.

The major area of damage was outside of the pressure hull and top side from about frame 10 to the stern of the vessel. Most of it was sustained on the port side and piping or equipment which was not shielded by hull structure or large pipe lines was also damaged on the starboard side. See photographs on pages 43 to 55 inclusive and 5 to 8 inclusive of Volume II.

(c) Primary cause of damage in each area of major damage.

Primary cause of damage was due to the pressure wave that the blast exerted on the starboard top side hull plating. This plating was torn loose and carried away with it most of the deck structure. In doing so it was hurled or pushed against and damaged piping, engine exhaust valves and mufflers. The mufflers on the starboard side probably would have been torn loose from their foundations regardless of the damage to hull plating in view of the large surface which was exposed to the pressure wave and also in view of the comparatively light straps which held them in place.

(d) Effect of target test on overall operation of machinery plant.

Notwithstanding the damage to piping, outboard exhaust valves and mufflers outboard of the hull, the operability of the machinery plant is unaffected. The engines and all machinery has been operated at full capacity and show no effects of the blast. It is of interest to note that throughout the ship there wasn't a single failure of glass thermometers, gages or machinery and piping supports. This, and the nature of damage, indicates that the equipment was not subjected to a severe shock but rather to a pressure wave which had a comparatively low initial velocity.

SECRET

USS SKATE (SS305)

B. Boilers.

Not applicable.

C. Blowers.

Not applicable.

D. Fuel Oil Equipment.

(a) Heaters.

No damage.

(b) Strainers.

No damage.

(c) Manifolds.

No damage.

(d) Fittings.

Forward and after fuel oil filling connections torn off ship at hull by blast along with surrounding superstructure and supports.

(e) Flexible fueling hose.

Stowed topside, undamaged by test; later, 3 of the 4 lengths were crushed by a tug, alongside. See photograph on page 56 of Volume II.

E. Boilers Feedwater Equipment.

Not applicable.

SECRET

USS SKATE (SS305)

F. Main Propulsion Machinery.

(a) Main and auxiliary engines.

1. Foundations.

No damage.

2. Casings and cylinders.

No damage.

3. Bearings, crank shafts, pistons, etc.

No damage.

4. Couplings.

No damage.

5. Fuel injection system.

No damage.

6. Superchargers.

No damage.

7. Governors.

No damage.

8. Inboard and outboard exhaust valves.

(a) Inboard valves all undamaged.

(b) Outboard valves:

No. 1. Undamaged (see photograph on  
page 57 of Volume II).

SECRET

USS SKATE (SS305)

Page 53 of 140 Pages

No. 2. Casting twisted off foundations, raised and moved inboard about 1/2 inch at after end, supported by exhaust elbow and piping. Closes satisfactorily but will not open more than 80% due to bent and misaligned operating linkage. Engine operated satisfactorily. See photographs on pages 58 to 60 inclusive and page 33 of Volume II.

No. 3. Undamaged (see photograph on page 61 of Volume II).

No. 4. Casting twisted and lifted off foundations; after end raised about 8 inches and pushed inboard about 12 inches, twisting of the valve box caused rupture of a welded seam in the outboard exhaust trunk between the valve box and the pressure hull; supported by exhaust elbow and piping. Closes satisfactorily but will not open all the way. Engine operates satisfactorily. Both 2 and 4 valve gaskets will be burned up if engines run for any period since gaskets are in path of and unprotected from hot exhaust gases. See photographs on pages 62 to 64 inclusive of Volume II.

Auxiliary engine valve. Undamaged, operative. (See photographs on pages 65 and 66 of Volume II.

#### 9. Mufflers and exhaust piping.

Numbers 2 and 4 mufflers ripped off and missing, having torn loose at the flange connection to the valve box. Numbers 1 and 3 mufflers and piping intact and operative. One securing strap on No. 3 muffler loose due to missing bolt. See photographs on pages 65 and 66 of Volume II.

SECRET

USS SKATE (SS305)

Auxiliary engine muffler ripped off and found on top of after engine room hatch. See photographs on pages 63, 65, 67, and 68 of Volume II.

10. Cooling system.

Operative. Intact inside ship. Some piping carried away topside; does not affect operation. The exhaust trunk cooling water connection for No. 2 main engine was ruptured and the upper exhaust valve box cooling water line was torn loose from the engine cooling water discharge line. The latter line was also badly twisted and torn, however it is capable of passing sufficient water to cool the exhaust trunk and valve box. The exhaust trunk cooling water connection for No. 4 main engine was ruptured; loss of water through the hole does not appreciably affect the cooling of the trunk. All cooling lines to auxiliary engine muffler were torn loose at the valve box casting. See photographs on pages 58 and 66 of Volume II.

G. Reduction Gears.

(a) Foundations and casings.

Undamaged.

(b) Gears and shafting.

Apparently undamaged. Operative. Not abnormally noisy.

(c) Bearings.

Undamaged.

**SECRET**

USS SKATE (SS305)

(d) Couplings.

Undamaged.

(e) Fittings.

Undamaged.

(f) Turning gears.

Undamaged.

Note: Inspected port and starboard main reduction gears while underway at various speeds up to full power. Reduction gears are in excellent operating condition.

## H. Shafting and Bearings.

(a) Bearings.

Undamaged.

(b) Bearings and bearing foundations.

Undamaged.

(c) Alignment.

A check of the tail shaft alignment was obtained by breaking the after coupling prior to drydocking. Both shafts were in excellent alignment. Rim measurements showed the port shaft to be 0.025" low (normal sag) and 0.006" inboard. The starboard shaft was 0.022" low and 0.000 inboard. Face measurements indicated that both port and starboard top edges of the coupling faces were 0.004" farther apart than the bottom edges. This is in the reverse direction

SECRET

USS SKATE (SS305)

from that to be expected as a result of the sag of the overhanging section of the tail shaft, but is so small as to be satisfactory. The coupling faces on both sides were exactly parallel in the horizontal plane through the shaft axis.

(d) Hull packing gland.

Undamaged.

(e) Thrust bearings.

Apparently undamaged from operation.

(f) Strut bearings.

Apparently undamaged from operation.

I. Lubrication System.

(a) Coolers.

Undamaged.

(b) Filters and strainers.

Undamaged.

(c) Purifiers.

Undamaged.

(d) Tanks (sump, settling, etc.).

Undamaged.

(e) Fittings (gauges, etc.).

Undamaged.

J. Condensers and Air Injectors.

Not applicable.

SECRET

USS SKATE (SS305)

K. Pumps.

(a) Booster drain pump.

Undamaged.

(b) Circulating pumps.

Undamaged.

(c) Trim pumps.

Undamaged.

(d) Drain pump.

Undamaged.

(e) Priming pumps.

Undamaged.

(f) Fuel oil pumps.

Undamaged.

(g) Lubricating oil pumps.

Undamaged.

(h) Distiller feed pumps.

Undamaged.

L. Auxiliary Generators.

Engine covered under Item F.

SECRET

USS SKATE (SS305)

Page 58 of 140 Pages

M. Propellers.

(a) Blades.

Undamaged.

(b) Caps, nuts, etc.

Undamaged. NOTE: Report based on operation up to standard speed and examination by divers.

N. Distilling Plant.

(a) Distillers.

Undamaged.

(b) Compressors.

Undamaged.

(c) Miscellaneous valves, fittings, gages, attached piping, etc.

Undamaged.

(d) Foundations.

Undamaged.

(e) Refrigerant piping and cooling coils.

Undamaged.

(f) Insulation and lagging.

Undamaged.

(g) Miscellaneous, valves, switches, controls, fittings, etc.

Undamaged.

SECRET

USS SKATE (SS305)

O. Refrigerating and Air Conditioning.

(a) Compressors.

Undamaged.

(b) Motors.

Undamaged.

(c) Condensers.

Undamaged.

(d) Foundations.

Undamaged.

(e) Refrigerant piping and cooling coils.

Undamaged.

(f) Insulation and lagging.

Undamaged.

(g) Miscellaneous, valves, switches, controls, fittings,  
etc.

Undamaged.

P. Winches, Windlasses, and Capstans.

(a) Foundations and bed plates.

Undamaged.

(b) Brakes and brake lining.

Undamaged.

SECRET

USS SKATE (SS305)

Page 60 of 140 Pages

(c) Gearing.

Undamaged.

(d) Drums, bearings, shafting.

After capstan drum deformed by blast and flying superstructure. After capstan shaft bent 30 to 40 degrees to starboard at hull. See photographs on pages 21, 22, 23, 69, and 70 of Volume II. All bearings uninjured. Forward capstan and anchor windlass undamaged.

(e) Hydraulic systems.

Undamaged.

(f) Fittings, valves, etc.

Undamaged.

Q. Steering and Diving.

(a) Steering rams and cylinders.

Not damaged.

(b) Hydraulic systems including pumps, piping, etc.

Not damaged.

(c) Bow plane tilting mechanism.

Not damaged.

(d) Bow plane tilting mechanism.

Not damaged.

(e) Stern plane tilting mechanism.

Not damaged.

SECRET

USS SKATE (SS305)

Page 61 of 140 Pages

(f) Foundations.

Not damaged.

(g) Miscellaneous (steering stands, valves, gauges, etc.).

Not damaged.

R. Elevators, Ammunition Hoists, Etc.

Not applicable.

S. Ventilation (Machinery).

(a) Battery ventilation blowers.

Not damaged.

(b) Battery air flow meters.

Not damaged.

(c) Engine air and ventilation induction hull valves and Mechanism.

Not damaged.

(d) Bulkhead flappers.

Not damaged.

(e) Foundations and mountings.

Not damaged.

(f) Fans and motors.

Not damaged.

SECRET

USS SKATE (SS305)

Page 62 of 140 Pages

T. Compressed Air Plant.

(a) High pressure air compressors.

Not damaged.

(b) Low pressure blower.

Not damaged.

(c) Foundations.

Not damaged.

(d) Coolers.

Not damaged.

(e) Air banks.

Not damaged.

(f) Torpedo impulse flasks.

Flasks themselves not damaged. After port flask (No. 6) for forward tubes displaced about 18 inches due to blast. Pipe ruptured. (See photographs on page 71 of Volume II). Middle flask, port, No. 4, for forward tubes displaced about 8 inches (top pushed up and inboard). Piping leaking. Other flasks and piping intact although forward port flask (No. 2) slightly out of place and piping bent.

(g) Miscellaneous gauges, attached piping, etc.

No damage other than in (f) above.

U. Diesels.

Not applicable.

SECRET

USS SKATE (SS305)

V. Piping.

(a) High pressure (3000#) air piping.

All piping is intact and has been tested and operated at its designed pressure.

(b) Main ballast tank blow (600#) air piping.

All piping is intact and has been tested and operated at its designed pressure.

(c) Service (200#) air.

All piping is intact and has been tested and operated at its designed pressure.

(d) Main and fuel oil ballast blow (10 psi) air lines.

The 10# blow lines to main ballast tanks number 1, 2A, 2C, 6A, 6C and to fuel oil ballast tanks 3A, 4A, 4B, 5A, and 5B are intact and undamaged. See photograph on page 56 of Volume II.

Connections to main ballast tanks 2B and 2D are made to a common line. The branch line to tank 2B has a 2 inch rupture at frame 53 and the line is pinched closed at the connection to the tank vent riser. The line to tank 2D is torn loose at the connection to the tank vent riser. See photographs on pages 72 and 73 of Volume II.

Piping serving main ballast tanks 6B and 6D is bent and twisted to such an extent that it was ruptured. Connections to the tank vent risers have been blanked off after test.

Piping serving main ballast tank number 7 was badly bent and twisted between frames 80 - 100 and was torn apart at frame 80. A section was removed by ship's force between frames 85 and 100, to provide access. Had the line been intact

SECRET

USS SKATE (SS305)

it could not have been used since the tank vent riser to which it was connected was ruptured. See photograph on page 74 of Volume II.

(e) Torpedo Impulse Air Piping.

All piping is intact and has been tested and operated at its designed pressure except as follows:

1. The impulse air flask for number six torpedo tube was pushed inboard about 18 inches by distortion of deck structure. This caused rupture of the flask line at its connection to the flask and at the hull. See photograph on page 71 of Volume II.

2. The impulse air flask for number four torpedo tube was pushed inboard about 8 inches at the top which resulted in the kinking of the connection between the flask and hull and its rupture.

(f) Engine air starting.

All piping is intact and has been tested and operated at its designed pressure.

(g) Engine shut down air piping.

All piping is intact and has been tested and operated at its designed pressure.

(h) Salvage air piping.

All salvage air piping within the pressure hull is intact. Most of the piping and valve operating gear outside of the hull is in a damaged condition or carried away. However, all cut out valves, except for main ballast tanks #2B, 2C, 2D and 6C are intact and tight. The valve for main ballast tank #7 was removed with the vent piping to which it was attached and the vent lines blanked off. The valve for tanks 2B, 2C and 6C leaked through their seats and were blanked off. Leaking through valve for tank #2D was caused by distortion of the flanged connection at the deck. This valve was removed and the connection blanked off.

SECRET

USS SKATE (SS305)

It would have been possible to furnish salvage air to all tanks except where the valves were damaged by replacing the damaged pipe and by operating the valve at the valve stem.

The nature of damage for each salvage station outside of the pressure hull is listed below:

Forward Torpedo Room Low Salvage: Pipe slightly bent. Gear and valve intact.

Forward Torpedo Room High Salvage: Pipe and valve operating gear pushed aft about 12 inches. Due to the universal joint, it is possible to operate the valve. The line is intact.

Forward Battery Room Low Salvage: Pipe badly bent and upper section torn off. Operating gear was pulled out of the valve stem and is missing. See photograph on page 4 of Volume II.

Forward Battery Room High Salvage: Pipe slightly bent. Operating gear was pulled out of valve stem.

Main Ballast Tank #2A: Pipe, valve and operating gear intact. However, access to it was blocked by damaged deck structure.

Main Ballast Tank #2B: Pipe torn off at valve flange. Operating gear was pulled out of valve stem. The valve was found to be in a leaking condition and had to be blank flanged to prevent venting the ballast tank.

Control Room High Salvage: Pipe and valve intact. Operating gear pulled out of valve stem.

Control Room Low Salvage: Top of pipe torn off. Valve and operating gear intact.

SECRET

USS SKATE (SS305)

After Battery Room High Salvage: Pipe and valve intact. Operating gear pulled out of valve stem.

Main Ballast Tanks 2C and 2D: Pipe torn off at valve flanges. Operating gear pulled out of valve stem. Distortion of valve caused leakage through seats and the flange connections to deck which made it necessary for ship's force to remove the valve for tank 2D and blank flange the connections. See photograph on page 13 of Volume II.

Safety Ballast Tank: Pipe and valve operating gear badly bent and could not be used. Valve is intact.

After Battery Room Low Salvage: Pipe torn off at valve flange. Operating gear was pulled out of valve stem. Valve is intact.

Forward Engine Room High Salvage: Pipe torn off at valve flange. Operating gear broken off above the yoke at the valve. Valve is intact.

Main Ballast Tank 6A: Pipe torn off at valve flange. Valve and operating gear intact. However, upper support for gear carried away.

Main Ballast Tank 6B and 6D: Pipe torn off at valve flanges. Operating gear was pulled out of valve stems. Valves are intact.

Main Ballast Tank 6C: Top part of pipe torn off. Operating gear was pulled out of valve stem. Valve was in a leaking condition and had to be blanked off by ship's force.

Forward Engine Room Low Salvage: Pipe badly twisted and operating gear broken off above the yoke at the valve. Valve is intact.

After Engine Room High Salvage: Top section of pipe torn off. Operating gear was pulled out of valve stem. Valve is intact.

SECRET

USS SKATE (SS305)

Maneuvering Room High Salvage: Pipe badly bent. Operating gear broken off above the yoke at the valve. Valve and pipe are intact.

After Engine Room Low Salvage: Pipe torn off at valve flange.

Maneuvering Room Low Salvage: Pipe slightly bent. Operating gear was pulled out of valve stem. Pipe and valve are intact. See photographs on pages 74 and 75 of Volume II.

After Torpedo Room High and Low Salvage: Pipes torn off at valve flanges. Operating gear was pulled out of valve stems. Valves are intact.

Main Ballast Tank #7: Pipe and valve intact. However, was removed with the tank vent line to which it was attached thereby making it inoperative. NOTE: Vent lines were damaged to such an extent that they had to be removed and tank connections blanked off.

(i) Main ballast tank vent piping.

Will be covered in Hull Report.

(j) Hull and battery ventilation piping.

Will be covered in Hull Report.

(k) Trimming system.

All piping is intact, has been tested and operated at designed pressure.

(l) Drain piping.

All piping is intact and has been tested and operated.

SECRET

USS SKATE (SS305)

(m) Magazine flooding piping.

All piping is intact and has been tested up to test casting.

(n) Plumbing piping.

All piping is intact and has been tested and operated at designed pressure.

(o) Fuel oil piping.

All piping is intact and has been tested and operated at designed pressure.

(p) Fuel oil compensating piping.

All piping within the pressure hull is intact and has been tested to designed pressure. However, the external main leading forward is badly bent and twisted between frames 75 and the hull connection at frame 90. It is completely severed at frame 75 and a kink at frame 65 has reduced its area about 35%. The vertical loop at frame 60 was also badly bent and twisted. At frame 85, the branch connection to number one and two main engine cooling water discharge line was torn off at the main line. The entire forward main has been made inoperative.

The main line leading aft from frame 90 was pushed outboard about 4 inches at frame 96. The line was also flattened in this area which reduced its cross sectional area about 25%. The branch line to the auxiliary diesel engine cooling water discharge line was torn apart between the outboard exhaust valve and the branch line check valve. Since the line appears to be otherwise intact and the check valve in the severed branch line should prevent loss of pressure, this main could be put into operation.

SECRET

USS SKATE (SS305)

(q) Lubricating oil piping.

All piping except the deck filling line is intact and has been tested and operated at designed pressure. The filling lines outside of the pressure hull were sheared off at the threaded connections to the hull and carried away.

(r) Hydraulic piping.

All piping is intact and has been tested and operated at designed pressures.

(s) Engine cooling salt water piping.

All piping within the pressure hull is intact and has been tested and operated at designed pressure. A minor leak occurred in the overboard discharge side of the auxiliary diesel engine cooling water line in the lower engine room. The nature of this leak indicates that it was caused by internal corrosion of the pipe and cannot be directly attributed to the explosion of the bomb. Damaged external piping is covered under main propulsion engine mufflers and exhaust piping.

(t) Engine cooling fresh water piping.

All piping is intact and has been tested and operated at designed pressure.

(u) Main motor cooling water (salt) piping.

All piping is intact and has been tested and operated at designed pressure.

(v) Distiller feed piping.

All piping is intact and has been tested and operated at designed pressure.

(w) Refrigeration circulating water piping.

All piping is intact and has been tested and

SECRET

USS SKATE (SS305)

operated at designed pressure.

(x) Air conditioning circulating water piping.

All piping is intact and has been tested and operated at designed pressure.

(y) Freon piping and coils.

All piping is intact and has been tested and operated at designed pressure.

(z) Air compressor circulating water piping.

All piping is intact and has been tested and operated at designed pressure.

(aa) Potable fresh water piping.

All piping is intact and has been tested and operated at designed pressure.

(bb) Battery water piping.

All piping is intact and has been tested and operated at designed pressure.

W. Hydraulic systems.

(a) Main hydraulic pumps.

Not damaged.

(b) Hydraulic accumulator.

Not damaged.

SECRET

USS SKATE (SS305)

(c) Main vent hydraulic operating mechanism.

Not damaged. Bow buoyancy and #7 main vent inoperable due to superstructure damage to mechanical linkage outside pressure hull. See photographs on pages 69, 22, and 23 of Volume II.

(d) Ballast tank flood valve hydraulic operating mechanism.

Not damaged.

(e) Engine air induction valve hydraulic operating mechanism.

No apparent damage. Inoperable due to structural damage topside.

(f) Ventilation induction valve operating mechanism.

Same item as (e) above.

(g) Main engine exhaust valve operating mechanism.

Numbers 1 and 3, no damage.

Numbers 2 and 4, no damage to hydraulic system.

Damage to mechanical linkage topside prevents full opening.

(h) Auxiliary engine exhaust valve operating mechanism.

No damage.

(i) Sound head lower/raise mechanism.

No damage to hydraulic system. Drift stops for starboard bottom sound head carried away when vessel beached. Shaft bent.

SECRET

USS SKATE (SS305)

(j) Hydraulic periscope lower/raise mechanism.

No apparent damage inside pressure hull.  
Inoperable due to bent periscope sheers and periscopes and ruptured external piping.

(k) Hydraulic hand pumps for sound heads.

Not damaged.

(l) Hydraulic SD radar mast lower/raise mechanism.

No apparent damage inside pressure hull.  
Inoperable due to bent mast sheers and mast and ruptured external piping.

(m) Bow plane hydraulic tilting mechanism.

Not damaged.

(n) Stern plane hydraulic tilting mechanism.

Not damaged.

(o) Bow plane hydraulic rigging mechanism.

Not damaged.

## X. Navigational instruments.

(a) Underwater log.

No apparent damage.

(b) Magnetic compasses.

No apparent damage.

SECRET

USS SKATE (SS305)

**Y. Periscopes.**

(a) Optics, bearings, train, stadimeter, etc.

Periscopes bent at about upper third of length.  
No apparent other damage. Unable to inspect foot of periscopes.  
Upper windows appear smoky, otherwise undamaged.

(b) Mechanical Hoist Mechanism.

Not applicable.

**Z. Radar and Sonar.**

(a) Mechanical hoisting mechanism.

Not applicable.

(b) Training mechanism.

SJ radar: Base of mast slightly sprung  
causing misalignment. Inoperable due to bent SJ mast.

Sonar: Undamaged. QLA sound head  
training mechanism inoperable due to bent shaft. See  
photograph on page 76 of volume II.

Starboard lower sound head (QB) inoperable due to bent  
shaft (from beaching).

**AA. Miscellaneous.**

(a) Submerged signal ejector. (control room)

Barrel and outer door broken off at hull.  
Operating shaft for outer door bent and pushed in to the extent  
that gears would not mesh inside hull and operating handle bent.  
See photographs on pages 77 and 78 of volume II.

SECRET

USS SKATE (SS 305)

## TECHNICAL INSPECTION REPORT

### SECTION III - ELECTRICAL

#### GENERAL SUMMARY OF ELECTRICAL DAMAGE

##### I. Target Condition after Test.

- (a) Drafts after test; list; general areas of flooding sources.

Not observed.

- (b) Structural damage.

Structural damage which contributed to electrical damage occurred only outside the pressure hulls. Most of the bridge superstructure and the deck superstructure aft of the conning tower was torn away or badly demolished by the blast. The deck superstructure forward of the conning tower and up to the forward torpedo room hatch was similarly damaged. The drum and shaft of the after capstan was bent over by the blast and rendered inoperable. Periscope shears and radar mast were bent out of position, rendering the periscope and radar hoisting gear inoperable. A detailed description of structural damage is contained in the Hull Technical Inspection Report.

- (c) Damage.

The significant electrical damage within the pressure hulls was confined to the propelling storage batteries, the master and auxiliary gyro compasses, the voltage and speed regulators for the three I.C. motor-generator sets, the motor for the after gyro setting indicator regulator, light bulbs in the after torpedo and maneuvering rooms. With the exception of the motor for the after gyro setting indicator regulator, all of this damage was a nature that could be repaired by the ship's crew. Outside the pressure hulls, all electrical equipment on the bridge and all lighting fixtures except the bow light were damaged, torn from supports or dislocated and was rendered inoperable due to such damage or due to shearing of cables.

SECRET

USS SKATE (SS305)

## II. Forces Evidenced and Effects Noted.

### (a) Heat.

There was no evidence of heat having affected any equipment inside the pressure hulls. Topside cables in a few instances, particularly those high on the superstructure and on the periscope shears, had a light covering of char or soot which could be rubbed off with the fingers. In no case was the insulation damaged due solely to heat. Heat also darkened the glass of the bridge gyro compass repeater and blackened or charred paint on bridge instruments.

### (b) Fires and Explosions.

None.

### (c) Shock.

Shock was the cause of all electrical damage within the pressure hulls, although rolling of the ship may have contributed to spillage of mercury from the master and auxiliary gyro compasses and the damage to the propelling battery tie-rods. Maximum shock apparently occurred in the after torpedo room. Paragraph I(c) lists electrical equipment within the pressure hulls that was damage due to shock.

Shock damage to electrical equipment consisted essentially of: mercury spillage from the gyro compasses, shattering of light bulbs, loss of adjustment of voltage and speed regulators for I.C. motor-generator sets, shearing of a battery tie-rod, shattering of a section of battery vent duct, dislocation of the motor for the after gyro setting indicator regulator, dislocation of two fuses, and the tripping of two controller overload relays.

SECRET

USS SKATE (SS305)

(d) Pressure.

There was no damage to electrical equipment directly attributable to pressure. However, electrical equipment on the bridge and topside lighting fixtures were damaged indirectly when the blast pressure demolished the superstructure.

(e) Any effects apparently peculiar to the atom bomb.

Besides radioactivity, the relatively extreme pressure effect was the only phenomenon noted that may be considered peculiar to the atom bomb.

III. Effects of Damage.

(a) Effect on propulsion and ship control.

None, other than loss of ship control from bridge station.

(b) Effect on gunnery and fire control.

Automatic feed of Own Ship's Course to the torpedo data computer was temporarily inoperable because of a derangement to the master gyro compass.

The power drive for the after gyro setting indicator regulator was inoperable due to a dislocated operating motor.

(c) Effect on watertight integrity and stability.

None from an electrical standpoint.

(d) Effect on personnel and habitability.

In addition to possible radiological effects, it is believed that all personnel exposed on topside would have

SECRET

USS SKATE (SS305)

been killed by the blast. Habitability within the pressure hulls was not impaired.

(e) Total Effect on Fighting Efficiency.

On the basis of electrical damage, the fighting efficiency would have been somewhat impaired by the necessity of feeding Own Ships Course to the torpedo data computer by hand during repairs, and by the loss of power operation for the after gyro setting indicator regulator.

IV. General Summary of Observers Impressions and Conclusions.

Although the superstructure of this ship was severely damaged and all topside personnel would have been killed, the material damage to electrical equipment vital to the ship's operation, surfaced or submerged, was relatively minor.

V. Any Preliminary General or Specific Recommendations of the Inspection Group.

The speed and voltage regulators of the I.C. motor-generator sets should be designed to comply with naval high impact requirements. Cables and electrical equipment outside the pressure hulls should be reduced to a minimum, and when essential, should be secured to sturdy structural members rather than to hull plating. Consideration should also be to shielding topside electrical equipment from the direct force of the blast.

The methods of securing propelling batteries in the wells and the battery vent duct installation should be improved to prevent displacement and damage due to shock.

SECRET

USS SKATE (SS305)

## DETAILED DESCRIPTION OF ELECTRICAL DAMAGE

### A. General Description of Electrical Damage.

#### (a) Overall Condition.

All vital electrical equipment was intact after the test and all such equipment was operable with the exception of the master and auxiliary gyro compasses and the motor for the after gyro setting indicator regulator. Electrical equipment outside the pressure hulls, consisting of lights, repeaters, transmitters and reproducers were damaged or displaced due to the failure of the superstructure from blast effects.

All of the damage to electrical equipment within the pressure hulls was of a nature that could be repaired by the ships crew with the exception of the motor for the after gyro setting indicator regulator.

#### (b) Areas of Major Damage.

Maximum damage to electric light bulbs occurred in the after torpedo room. The control room and the battery compartments were the other areas in which damage to electrical equipment predominated inside the pressure hulls, although none of this electrical damage can be considered of a major nature.

Major damage to electrical equipment outside the pressure hulls occurred in the superstructure comprising the bridge and that aft of the conning tower.

SECRET

USS SKATE (SS305)

- (c) Primary causes of damage in each area of major damage.

The primary cause of electrical damage with in the pressure hulls was shock. Electrical damage outside the pressure hulls was primarily due to pressure wave which tore away or demolished the superstructure on which electrical equipment was mounted.

- (d) Effect of target tests on overall operation of electric plant.

1. Electrical Propulsion.

No effect, Operable.

2. Main Storage Batteries.

Minor shock damage occurred, but not sufficient to impair operability seriously.

3. Auxiliary Power.

Minor shock damage occurred to some electrical equipment included in this system, but not sufficient to impair operability seriously.

4. Communications.

Automatic voltage and speed regulators for the three I.C. Motor-generator sets were inoperable, necessitating manual speed and voltage control. Communication systems are otherwise operable except at the bridge station.

5. Fire Control Circuits.

The automatic feed of Own Ships Course to the torpedo data computer was temporarily inoperable due to a

SECRET

USS SKATE (SS305)

derangement to the master gyro compass. The after gyro setting indicator regulator was inoperable due to dislocation of its operating motor, as shown in photograph on Page 30 of Volume II.

6. Lighting.

Operable except that a total of eight light bulbs were damaged inside the pressure hulls. All lights outside the pressure hulls were inoperable, with the exception of the bow light.

7. Ventilation.

Operable.

(e) Types of equipment most affected.

1. Switchboards and switch gear.

The voltage regulators for the three I.C. motor-generator sets.

2. Rotating machinery.

The speed regulators for the three I.C. motor-generator sets.

3. Motor controllers.

Controllers for I.C. motor-generator sets.

4. Cables and supports.

DCP cables and supports in the bridge and superstructure aft of the conning tower.

SECRET

USS SKATE (SS305)

5. Interior communications and fire control.

Master and auxiliary gyro compasses, bridge repeaters, transmitters and reproducers.

B. Electric Propulsion Rotating Equipment.

No damage.

C. Electric Propulsion Control Equipment.

No damage.

During the operational checks the battery overload relays functioned while the propelling batteries were supplying propulsion power in the "Series 3" arrangement. The excessive current was found to be due to the fact that the packing in the stern tubes had been tightened by the ship's crew prior to the test. Satisfactory operation resulted after the packing was loosened somewhat.

Refer to Item T for damage to port shaft speed indicator.

D. Generators - Ships Service.

Not Applicable.

E. Generators - Emergency.

Not Applicable.

F. Switchboards, Distribution and Transfer Panels.

No damage occurred other than as specifically noted herein, namely:

SECRET

USS SKATE (SS305)

(a) Power distribution panel No. 2-55-2.

A one-hundred ampere knife blade type fuse was jarred out of place on the positive side of the main line switch, but was not damaged. This panel is located on the after bulkhead of the control room and controls the power supply to the radio room, trim pump and hydraulic pumps. The knife switches and fuses on this panel do not have lock-in devices. In modern naval equipment, lock-in devices would have been provided and would have prevented any similar derangement.

(b) Voltage regulators for I.C. motor-generator sets.

The three automatic voltage regulators for the three I.C. motor-generator sets operated erratically when checked and were not capable of maintaining the A-C voltage constant. There was no visual evidence of damage to the regulators and the trouble is believed to be due to loss of adjustment. The I.C. motor-generator sets were subsequently operated on manual voltage control only.

The regulators for No. 1 and No. 2 I.C. motor-generator sets are Ward Leonard units and are mounted in the pump room, on the port side. The regulator for No. 3 I.C. motor-generator set is believed to be a Cutler-Hammer unit and is mounted on the set, which is supported from the overhead in the after engine room.

The settings of these voltage regulators are apparently sensitive to shock. The magnitude of the shock in the vicinity of the regulators was of a relatively low order as lights and other sensitive equipment in the vicinity of any of these regulators were not damaged.

Recommendations.

The automatic voltage regulators for the I.C. motor-generator sets should be designed to comply with current naval high impact requirements.

SECRET

USS SKATE (SS305)

G. Wiring, Wiring Equipment and Wireways.

(a) Cables.

Cables inside the pressure hulls were not damaged. The DCP cables in the bridge superstructure and amidship under the deck were sheared or pulled out of place where the superstructure was torn away or demolished by the blast. The cables supplying the stern light, running and side lights, bridge receptacles, bridge contact makers and bridge instruments, and the signal searchlight, were sheared in two when superstructure failed. The rubber insulation on the cables was not damaged by heat or pressure, although paint on cables exposed directly to the blast was scorched.

(b) Wireway Supports.

Wireway supports within the pressure hulls were not damaged. Cable supports outside the pressure hulls failed or deformed where superstructure failed and pulled the cables away from hull structure. Where supports failed, the screws securing the ends of the cable straps usually sheared. In some instances the cable supports remained intact despite the fact that the force exerted on the cable was sufficient to shear them.

(c) Connection and junction boxes, receptacles and plugs.

The only damage observed occurred to a feeder junction box in the after engine room and to receptacles outside the pressure hulls.

A thirty-ampere fuse was jarred out of position in the junction box for feeder 2FB-101. This box is a

SECRET

USS SKATE (SS305)

Page 84 of 140 Pages

9-S-4232-L, watertight box, located on the port side of the after engine room. The fuse was not damaged. No fuse retainers were installed. If fuse retainers had been provided, as in modern naval equipment, this derangement would not have occurred.

A few mounting lugs and mounting screws were sheared off pressure-proof receptacles located on the bridge where the superstructure deformed considerably.

There was no visible evidence of damage to stuffing tubes for DCP cables passing through the pressure hulls. There was no apparent slippage of cables despite the fact that some of the DCP cables had been sheared at short distances from the tubes.

In general the damage which occurred to cables, cable supports and receptacles in the superstructure was due to hull structural failures rather than to any direct effect of the bomb.

Condition of topside cables and electrical equipment is shown in photographs on Pages 6, 8, 32, 46, 53, 56 and 79 of Volume II.

#### Recommendations.

It would appear desirable to keep the amount of wiring and wiring equipment located outside the pressure hulls to a minimum. When such equipment is required, it should be secured to sturdy structural members rather than to hull plating. Consideration should also be given to shielding topside electrical equipment from the direct force of the blast.

#### H. Transformers.

No damage.

SECRET

USS SKATE (SS305)

Page 85 of 140 Pgges

## I Submarine Propelling Batteries.

Some damage occurred due to shock, as noted below in detail. However, the ship's crew was able to effect repairs so as to permit operating both batteries. The batteries were fully charged and on open circuit during the test.

Analysis of electrolyte samples after the test by the Pearl Harbor Naval Ship Yard revealed no significant changes attributable to the atom bomb.

### (a) Jars.

No damage.

### (c) Covers.

Nine cell breather caps were dislodged from both batteries.

### (c) Wedges and strongbacks.

In the forward well a tie-rod on the starboard side, between cells 31 and 32, sheared off at the base of the retaining nut. At a second tie-rod on the starboard side between cells 26 and 27, the two steel backing plates were deformed. In both cases the wooden wedges on the inboard side near these cells were loose but not broken. This damage appears to have been due to the pressure of the cells against the inboard longitudinal channel on the starboard side, as the result of shock and rolling. It is possible that the loosened wedges may have been somewhat loose prior to the test which would explain why the damage was limited to two tie-rods. The sheared tie-rod is shown in photograph on Page 19 of Volume II.

### (d) Busbars and connections.

No damage.

SECRET

USS SKATE (SS305)

(e) Acid spillage.

A small amount of acid spillage occurred in both battery compartments, apparently splashing out around the cell breather caps.

(f) Ventilation ductwork.

In the forward well the two collars which secure the vent tubing for cells 50 and 53 to the main vent duct, were broken in two. This apparently was caused by impact between this section of duct and cables immediately overhead. The clearance between ducts and cables was about six inches. Temporary repairs were effected by the ship's crew. The forward battery vent duct damage is shown in photograph on Page 29 of Volume II.

Recommendations.

Battery cell breather caps should be secured adequately so as to prevent their dislodgement under shock.

Sturdier tie-rods between the individual cells are recommended.

Deck plates located over the center rows of cells should be adequately secured in place to prevent their dislodgement under shock.

Adequate clearance should be provided between all vent ductwork and structure or equipment to prevent damage from impact due to movement of ducts and jars under shock.

Instructions in Bureau of Ships Manual of Engineering Instructions should stress the importance of maintaining the battery wedges fitted tightly and of checking them regularly.

SECRET

USS SKATE (SS 305)

J. Portable Batteries.

Not Applicable.

K. Motors, Motor-Generator Sets and Motor Controllers.

(a) Rotating equipment.

No damage occurred except as specifically noted below.

1. I.C. Motor-generator sets.

The speed regulators for all three sets functioned erratically when tested. No damage was apparent from visual inspection of the assembled units. The trouble apparently can be remedied by regulating the internal settings of the regulators. The adjustments of these regulators are apparently critical and easily altered by shock, even of relatively low order.

The speed regulators for No. 1 and No. 2 I.C. motor-generator sets are Ward-Leonard belt-driven units and the regulator for No. 3 set is a Cutler-Hammer unit. The regulators are mounted on the motor end of the sets and all three sets are supported on rubber spaces.

The three I.C. motor-generator sets were being operated with their speed regulators and voltage regulators cut out of service. For derangement to the voltage regulators, refer to Item F.

Recommendations.

The speed regulators for the I.C. motor-generator sets should be designed to comply with current naval high impact requirements.

SECRET

USS SKATE (SS305)

2. Hydraulic steering engine motor.

One brush on the underside of the commutator was dislodged from its holder and was suspending by its pigtail. Brush retainers are provided but these apparently had been bent out of position prior to the test as the brushes cannot be removed for inspection conveniently without removing or bending the retainers. This motor was manufactured by the Star Electric Company and is rated fifteen horsepower. It is mounted from the overhead on the centerline above the tubes in the after torpedo room.

Recommendations.

Brush retainers for D.C. motors should be designed so as to permit removal of brushes without necessitating the removal or forcing of brush retainers.

(b) Control Equipment.

No damage occurred except as specifically noted below.

1. Controllers for No. 1 and No. 2 I.C. Motor-generator sets.

The overload relays tripped open but no visual damage was evident and the controllers were operated satisfactorily after the relays had been reset. These controllers are Ward-Leonard units and are located on the starboard side of the control room. These controllers are not in accordance with naval high impact shock requirements as would be the case in more modern submarines.

L. Lighting Equipment.

No damage occurred except as specifically noted below:

SECRET

USS SKATE (SS305)

(a) Lamps.

Six rough service, 50 watt bulbs were shattered in the after torpedo room due to shock transmitted through the hull. These lamps were located forward of the torpedo tubes. Lamps directly over the torpedo tubes and in the watercloset and store-room were not damaged. Four of the damaged lamps were mounted in non-watertight 9-S-4665-L ceiling fixtures, and two in watertight bulkhead fixtures from which the blue globes had been removed prior to the test.

One high impact General Electric frosted 50 watt bulb in a 9-S-4665-L ceiling fixture in the after torpedo room did not shatter but the filament apparently broke under shock.

All the torpedo room ceiling fixtures are supported by steel straps welded to the hull, and bulkhead fixtures are supported to stiffeners or to the forward bulkhead. Felt washers are located between the fixtures and their supports.

One rough service bulb in a maneuvering room ceiling fixture, immediately aft of the propulsion control cubicle, was shaken from its fixture. This fixture was mounted semi-rigidly with rubber spacers, which allowed the fixture to vibrate under shock. This particular bulb may have been somewhat loose in its socket as other bulbs similarly mounted in the maneuvering room were not damaged.

A number of twenty-four inch fluorescent tubes supported in fixtures which are suspended from the overhead in the crews quarters and the control room were not damaged. However, one or more of the four suspending chains supporting each fixture broke.

Outside the pressure hulls, the stern light and the sidelights were demolished or badly damaged when the superstructure failed. The masthead light was intact despite the fact

SECRET

USS SKATE (SS305)

that the periscope shear on which the light is mounted was bent by blast. The condition of topside lighting fixtures is shown in photographs on Pages 46 and 53 of Volume II.

Recommendations.

The number of topside lights should be reduced to a minimum. Essential lights should be sturdily supported and shielded as far as practicable from blast effects.

M. Searchlights.

The 12-inch searchlight had been removed prior to test able and placed inside the conning tower. However, the supporting structures for this light was badly demolished by the blast. The searchlight undoubtedly would have been damaged beyond repair had it been mounted in place.

N. Degaussing Equipment.

Not applicable.

O. Gyro Compass Equipment.

(a) Master

The master gyro compass spilled mercury from the oscillating bowl due to shock and possibly due to rolling. The south rotor vacuum decreased from 26 inches to 15 inches. This compass is located in the control room and is an Arma, Mark VII, Mod. 3 unit.

The loss of vacuum may not have been due to the bomb effects as some difficulty maintaining vacuum existed prior to the test. The compass could not be operated until repaired by the ship's crew.

SECRET

USS SKATE (SS305)

It is understood that gyro compasses of more recent design are less susceptible to mercury spillage under shock.

(b) Repeaters.

No damage occurred to repeaters within the pressure hull. The bridge repeater appeared intact, but could not be operated as its cable was sheared. Its glass window was darkened by radiant heat.

(c) DRT and DRA.

No damage.

(d) Auxiliary.

The auxiliary gyro compass spilled mercury due to shock and possibly due to rolling. This compass is located in the control room and is an Arma, Mark IX, Mod. 2 unit.

This compass could not be operated but it is believed that the ship's crew could effect repairs.

This type of Arma compass is susceptible to mercury spillage under shock as similar failures have occurred on other target submarines in Test Able and Baker. However, it is understood that this compass is now obsolete.

P. Sound Powered Telephones.

No damage.

Q. Ship's Service Telephones.

Not Applicable.

SECRET

USS SKATE (SS305)

R. Announcing Systems.

(a) Portable (PAM and PAB)  
Not applicable.

(b) Amplifier racks.

Not applicable.

(c) Control racks.

Not applicable.

(d) Transmitting Station.

Intact except for bridge.

(e) Reproducers.

IMC and 7MC reproducers were missing on  
bridge.

(f) Inter-Communication Units.

Intact except for bridge.

Condition of announcing system equipment on  
topside is shown in photographs on Pages 8 and 32 of Volume II.

S. Tele. phs.

No damage.

T. Indicating Systems.

Rudder angle indicator on bridge was missing.

SECRET

USS SKATE(SS305)

The port shaft speed indicating meter registered 16 RPM at zero shaft speed and read 16 RPM higher than correct speed. It is believed that shock has disturbed the internal settings of this meter.

The starboard shaft meter was not damaged although both meters are mounted on the propulsion control cubicle. The speed meters were manufactured by Electric Tachometer Corporation.

Recommendations.

Shaft speed indicators should be designed to withstand naval high impact shock requirements.

U. I.C. and A.C.O. Switchboards.

No damage.

V. F.C. Switchboards.

No damage.

SECRET

USS SKATE (SS305)

Page 94 of 140 Pages

APPENDIX

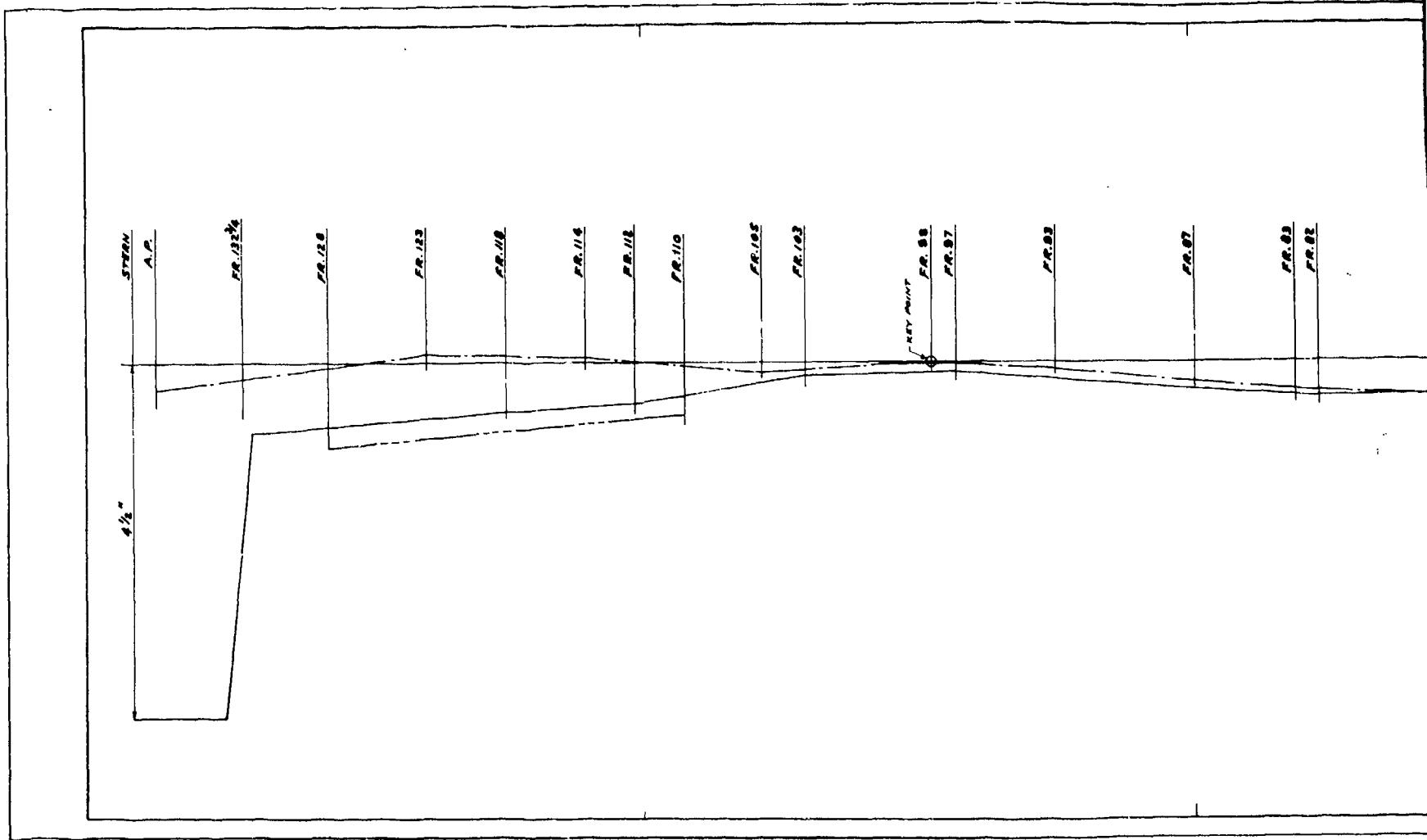
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TEST BAKER

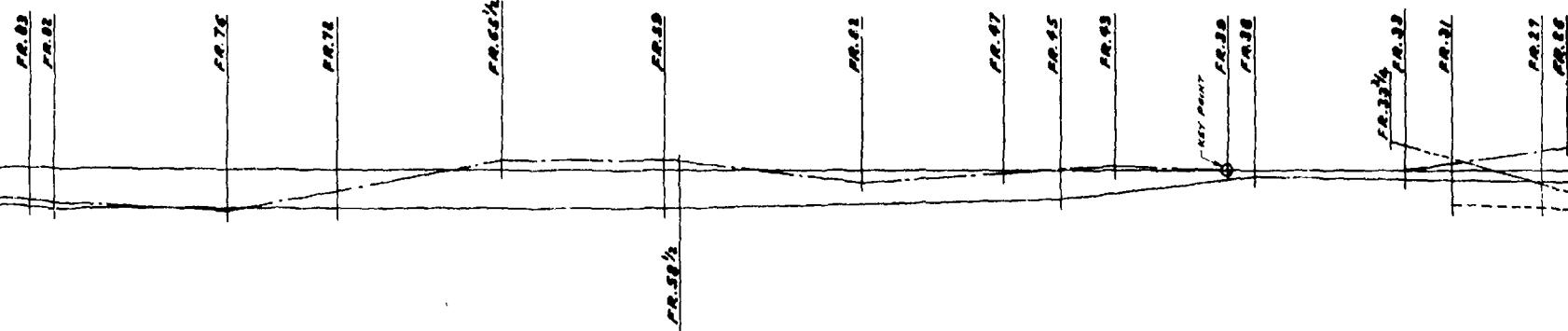
SECRET

USS SKATE (SS305)

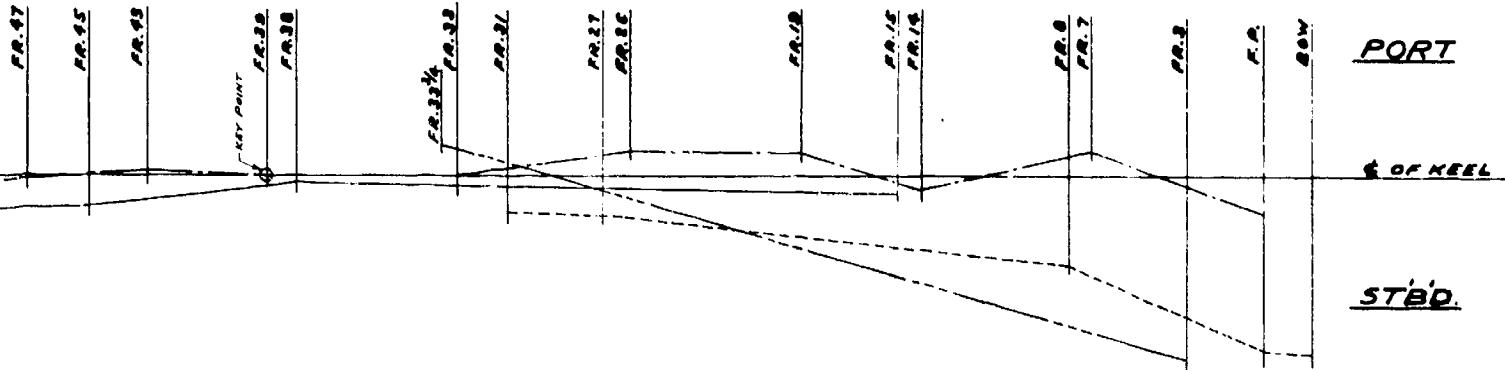
Page 95 of 140 Pages



LONG'L SCALE: 1/8" = 1'-0"  
TRANSV SCALE: FULL SIZE



2



—S OF TORPEDO TUBE NEST

SECRET

**PLATE I**

PLOT OF HULL DISTORTION  
TESTABLE  
TAKEN IN DRYDOCK AT MARE  
ISLAND NAVAL SHIPYARD  
NOV. 4-10<sup>th</sup> 1946  
U.S.S. SHAWEE 58308

PAGE 36 OF 100 PAGES

3

	MUZZLE DOOR				SHUTTER				DISTANCE FROM MUZZLE BORE GAGE ENTERED TUBE	
	AT TUBE		OUTER END		TUBE END		OUTER END			
	ACTUAL AT ARRIVAL	PLAN DIMEN.	ACTUAL AT ARRIVAL	PLAN DIMEN.	ACTUAL AT ARRIVAL	PLAN DIMEN.	ACTUAL AT ARRIVAL	PLAN DIMEN.		
FORWARD TUBES	1 10 7/8"	11 1/16" + - 1/16"	10 7/8"	11 1/16" + - 1/16"	11 3/4"	12" +.000 -.025	12 1/2"	13" + - 1/8"	16 1/4"	
	2	11 1/8"	DO	11 3/8"	DO	CUT OUT	DO	CUT OUT	DO	
	3	11 1/8"	DO	11"	DO	11 1/2"	DO	13 5/8"	DO	
	4	10 13/16"	DO	10 15/16"	DO	11 3/4"	DO	12 15/16"	DO	
	5	10 15/16"	DO	11"	DO	11 15/16"	DO	13 1/8"	DO	
	6	11 1/16"	DO	10 15/16"	DO	12"	DO	13 1/4"	DO	
AFT. TUBES	7	11 1/16"	DO	10 7/16"	DO	CUT OUT	DO	CUT OUT	DO	
	8	11 1/2"	DO	11 7/8"	DO	CUT OUT	DO	CUT OUT	DO	
	9	11"	DO	10 1/8"	DO	CUT OUT	DO	CUT OUT	DO	
	10	10 13/16"	DO	9 3/4"	DO	CUT OUT	DO	CUT OUT	DO	
SECRET										
PLATE II										
U.S.S. SKATE (SS 305)										

APPENDIX

COMMANDING OFFICERS REPORT

TEST ABLE

SECRET

USS SKATE (SS305)

Page 98 of 140 Pages

REPORT #11

COMMANDING OFFICER'S REPORT

SECTION I

General Condition of Vessel Before Test "A"

- A. Name -- U.S.S. SKATE (SS305)
- B. Type -- Submarine - heavy hull
- C. Location in target array -- Directly astern of U.S.S. NEVADA in berth 161.
- D. General discussion of material condition.
  - (a) Mooring -- On the surface, moored fore and aft to buoys on heading 085°T. Sixty-one fathoms of anchor chain from hawse pipe to forward buoy (this buoy also served as stern buoy for NEVADA) 275 feet of 1-1/4" wire from towing padeye to after buoy, leading through stern chock.
  - (b) Rig for A-Bomb -- Ship was rigged in accordance with a bill prepared on the basis of general outline in Submarine Supplement to "Instructions to Target Vessels for Tests and Observations by Ship's Force".
  - (c) Loading accordance DSM loading instructions of 11 March 1946.
    - 1. Fuel - 36.000 gallons (1/3 capacity).
    - 2. Ammunition - 66% gun ammunition and torpedoes plus seven special torpedoes.

SECRET

USS SKATE (SS305)

## SECTION II

### GENERAL SUMMARY

#### I. Target Condition After Test.

(a) Draft on July 2 was approximately 16' forward and 17' aft, an increase of about one foot (SKATE was aground forward). There was a slight list to starboard. The only flooding occurred in the main ballast tanks. No. 7 vent was forced open, probably by the after capstan striking it. No. 2B, 2C, 2D, 6B and 6C vented through the salvage connections.

(b) Structural damage. The superstructure was mangled by the blast. The bridge was turned inside out leaving the ~~conn-~~ tower exposed. All the deck was gone abaft the forward escape trunk except small part around the after battery hatch and a small section aft of the forward gun mount. The pressure hull, ballast tanks and compartments were all intact.

(c) Operability. All machinery, electrical ship control and electronics gear was operable with the exception of the power drive on the after gyro setter indicator regulator. Topside the after capstan, number 7 main ballast tank vent, radio and radar antennae, and the only gun mounted were all rendered inoperable.

(d) There was no evidence of fire. Paint was somewhat scorched on surfaces toward the explosion, but maximum temperatures below decks were little higher than normal (94° in For'd torpedo room, 86° in magazine. Manila lines in lockers in the superstructure were in good condition. Disregarding effects of radio-activity, it is estimated there would have been no casualties below decks, while all topside personnel would have been killed.

#### II. Forces evidenced and effects noted.

(a) Heat. There was no apparent effect except for scorched surface which were facing the port quarter.

SECRET

USS SKATE (SS305)

(b) Fires and explosions.

None evident.

(c) Shock.

None noted.

(d) Pressure. The blast came from the port quarter. It twisted and bent the superstructure toward the starboard bow. The periscope shears and SD mast were bent forward and to starboard. The blast apparently caused the ship to take a large roll to starboard. There were but few broken light bulbs and no loose cork insulation. Electrical meters were in good condition.

(e) Apparently the SKATE was very radioactive for several days. On Able plus 3 the Geiger counters showed a condition deemed safe for six hours only.

### III. Results of Test on Target.

(a) Effects on propulsion and ship control.

None.

(b) Effect on gunnery and fire control.

All topside armament was knocked out. Six torpedo tubes remained in good condition and all fire control equipment was operable but there remained no means of obtaining accurate ranges or bearings.

(c) Effect on water-tight integrity and stability.

None

SECRET

USS SKATE (SS305)

(d) Effect on personnel and habitability.

None except a slight inconvenience moving around topside among the wreckage and the necessity of leaving the ship unmanned until the radioactivity had diminished to a safe degree.

(e) Total effect on fighting efficiency.

Fighting efficiency was reduced about 90%. At present only a night surface torpedo attack could be made. Bearings and ranges would necessarily be estimated.

IV. General Summary.

An atomic bomb used in this manner is a very inefficient weapon against submarines. It is believed that a submarine submerged only to periscope depth alongside the SKATE in this test would have sustained very little damage.

V. Preliminary Recommendations.

The obvious lesson from this test is reduce topside fittings and piping.

SECRET

USS SKATE (SS305)

## COMMANDING OFFICER REPORT

### PART - III

#### SECTION I - HULL

##### A. General Description of Hull Damage.

(a) Overall condition of vessel. The pressure hull and outer hull were intact. The superstructure was severely mangled.

(b) General areas of hull damage. The tank tops were dished in slightly on the port side around frame 80. This was possibly caused by a heavy falling object as the condition was not general. Frame 55 appeared to be slightly pulled away from the pressure hull for about 3-inches apparently due to the force of the blast against the conning tower.

(c) Principal areas of flooding with sources. There was no interior flooding. No. 7 main ballast tank flooded when the vent was damaged by the after capstan being forced against it. No. 2D flooded because the 10# blow line was broken off at the vent riser. No. 2B, 2C, 6B and 6C flooded slowly because of damaged salvage connections.

(d) Residual strength, buoyancy and effect of general condition of hull on operability. The strength of the hull is apparently unchanged. Reserve buoyancy was temporarily decreased by the flooding of several main ballast tanks, however, this condition was completely remedied during the first day on board after the test. In regard to operability, boats have returned from war patrols with damage more serious than the SKATE has incurred.

SECRET

USS SKATE (SS305)

Page 103 of 140 Pages

B. Superstructure and Weather Decks.

(a) Description and causes of damage.

1. (a) Forward of conning tower. The superstructure between the conning tower and the forward torpedo room hatch was demolished except for a small portion on starboard side. The superstructure was intact forward of the torpedo room hatch. All damage appeared to have been caused by the blast.

(b) Decks and framing. The wooden deck was demolished except for the area bounded by the conning tower, gun foundation and starboard side. This section was shielded from the blast by the conning tower. Framing was twisted and broken.

(c) Vertical plating. Vertical plating on the starboard side was practically undamaged back to frame 50. On the port side it was intact from the stern to the bow plane to the torpedo room hatch and was missing from there aft except for small sections pushed in around the gun foundation. These sections were so distorted as to be nearly unrecognizable.

(d) Fittings. The submerged signal gun was broken off at the pressure hull. The distorted barrel was lying on the tank top. Compartment and main ballast tank salvage connections were bent or broken. The fittings forward of the torpedo room hatch were intact both above and below the deck.

(e) Foundations. The deck gun and 40MM gun foundations were intact. The foundation No. 5 for the port bank of impulse flasks is formed by the vertical side plating. This was blasted in, causing damage to the impulse piping. All the foundations forward were intact (bow planes, windless, capstan, etc.).

2. (a) Conning tower fairwater. The conning tower fairwater was demolished by the blast, leaving

SECRET

USS SKATE (SS305)

the conning tower and main induction exposed.

(b) Decks and framing. The decks were missing, and the small amount of framing that remained was twisted and broken.

(c) Vertical plating. Vertical plating forming the bridge was blown forward and wrapped around the forward 40MM gun. Most of the remainder was missing.

(d) Fittings. The antenna trunk was broken at the flange. The periscoper, SD mast, and shears were bent forward and to starboard. All stanchions, rails, and machine gun mounts were missing. Two 40 MM ready lockers were missing. 50 cal. machine gun stowage in periscope shears foundation was intact. 5" ready locker aft was intact but superstructure surrounding it was missing.

(e) Foundations. The periscope shears foundation was intact.

3. (a) Aft of conning tower. The superstructure aft of the conning tower was demolished by the blast.

(b) Decks and framing. There is one small section of wooden deck aft of the after battery hatch. The remainder of the deck, wood and metal, is missing. Superstructure framing is 90% missing on the port side and on both sides aft of the engine rooms. On the starboard side it is intact from the gun sponson to the after battery hatch.

(c) Vertical plating. All vertical plating on the port side is missing. On the starboard side there is badly distorted plating along the vicinity of the engine rooms and plating in good condition from the gun sponson to the after battery hatch. From this hatch to the forward end of the conning tower-on the starboard side-deck, framing, and vertical plating is missing. This section should have been shielded from the blast by the conning tower.

SECRET

USS SKATE (SS305)

(d) Fittings. Both port mufflers were gone. The auxiliary engine muffler was torn from its foundation and was perched on top of the after engine room hatch. Both starboard mufflers were intact but loose on their foundations. Salvage piping was bent and broken. Engine exhaust valves on the port side were slightly damaged, having been displaced to starboard. The after capstan was bent forward against No. 7 MBT vent. The ammunition scuttle was intact.

(e) Foundations. The 5" gun foundation aft was in good condition.

4. (a) Miscellaneous stowages in superstructure. All ammunition stowages were in good condition. The mooring line locker at frame 100 was missing. The one at frame 70 was licking one side. The locker at frame 45 starboard was 90% intact. The one at frame 45 port was missing three sides, but a manila line stowed in it during the test was in good condition - not even scorched.

(b) Evidence of fire. Paint on surfaces toward the blast was scorched, but there was no evidence of fire.

(c) Various plating thicknesses. The blast had no effect on the pressure hull, possible very slight effect on exposed part of the lighter outer hull, and devastating effect on the light superstructure. A contributing factor in the superstructure damage was the comparatively weak framing.

(d) Various shaped surfaces. A test 50 gallon oil drum in the superstructure was collapsed, the S.T.S. ammunition ready lockers were not even dented.

(e) Surfaces at various angles to line of attack. No differences noted.

(f) Surfaces having difference in types of covering. No difference noted.

(g) S.T.S. compared to MS. The S.T.S. ammunition ready lockers withstood the blast, but this was probably

SECRET

USS SKATE (SS305)

as much due to their shape and heavy construction as to the type of steel. The bridge armor, along with the rest of the bridge, was torn loose, but the S.T.S. plates were intact. No conclusive comparison can be made.

(h) Constructive criticism of superstructure design or construction. Criticism of superstructure design in the light of this test naturally falls in line to eliminate or minimize the resultant damage. This can best be achieved on a submarine by reducing the amount of topside fittings and piping. The essential parts of the superstructure should be strengthened, the remainder removed.

C. Turrets, Guns, and Directors.

(a) Guns - The forward 40 MM gun is a total wreck. Whether much of this damage was caused by the bomb is difficult to determine. Since the bridge structure has wrapped itself around the gun it seems this caused the damage and evidently the only direct bomb damage was scorched paint. All gun foundations are intact.

(b) Target bearing transmitter foundations - The after TBT was completely carried away, foundation and stand included. The forward TBT was found securely fastened to the bridge splash plate, however, the wrecked bridge structure made the TBT useless. The instrument itself is only slightly damaged, the binoculars are cloudy and the locking device is broken.

(c) Periscopes and Radar masts.

1. General condition of shears - The conical section of the shears was torn from its foundation by the bomb and pushed to starboard 30 degrees. All appendages except the masthead light, underwater antenna loop, and VHF antenna, all damaged. The foundation of the shears which consists of the section welded to the conning tower and extending up to the conical section was undamaged. The radar mast was bent over 30 degrees to the starboard from the bridge deck level, torn 270 degrees of its circumference there. The forward part of the radar

SECRET

USS SKATE (SS305)

mast foundation was not damaged, the supports which run diagonally from the pressure hull to the mast support at bridge deck level were badly distorted.

(d) Constructive criticism of design and construction - The shears and mast are too high in relation to their strength to withstand a shock such as resulting from the Atomic bomb. Either stays must be provided, the shears lowered, or the shears must be constructed as one piece, thus eliminating the bolted sections which showed the greatest weakness.

D. Torpedo Tubes and Appurtenances.

(a) Tubes.

1. All tubes are in normal condition except No. 7 and 8 whose outer doors and shutters are damaged. The entire upper shutter carriage is moved to starboard making the shutters of Nos. 7 and 8 tubes inoperable. No. 7 outer door is sprung open although not enough to admit any appreciable amount of water. On the surface. No. 8 outer door is sprung open about an inch, the shutter being badly pushed in. The tube was flooded.

(b) Cradles and loading gear - All cradles except the port upper inboard in the forward torpedo room, which carried a Mk. 27 torpedo, were damaged slightly. Apparently when the ship rolled sharply the inertia of the heavy torpedoes caused the cradle to tip. As a result all securing pins are distorted, making it impossible to lock and unlock the cradles without applying a great deal of force to the locking device. All loading equipment topside such as deck skids, single block fairways, and skid supports were carried away.

(c) Air flasks and warheads.

1. The general condition of the impulse bottles was good. However, Nos. 4 and 6 were pushed inboard

SECRET

USS SKATE (SS305)

which ruptured the impulse lines No. 6 immediately below the bottle flange and No. 4 line was torn out of the bottle flange. The warheads were all intact except for a hole in the warhead contained by the starboard lower cradle in the after room. This was caused by a heavy steel crosspiece which flew across the room, striking the warhead, and puncturing it.

2. The impulse bottles are not adequately protected from a blast of the force caused by the A-bomb. A remedy would be to secure them more firmly. The warheads require no further protection it seems.

(d) Constructive Criticism.

The damage to the cradles could probably have been avoided by a cradle designed with two securing pins on each locking device. Designing the location of the forward carrier beam so that it would be directly under the center of gravity of the warhead would prevent the forward part of the cradle from assuming almost the entire weight of the warhead. An additional carrier frame in this location would serve the purpose.

Elimination of the shutters aft would probably have prevented any damage to the torpedo tube outer doors. The shutters forward show no evidence of damage, however, had they been subjected to the same force they undoubtedly would have been damaged. A suggested strengthening of the shutters and roller paths might eliminate damage.

The damage sustained by the impulse lines might have been prevented had the bottles been more firmly secured in place. Locating the bottles inside the pressure hull, as they are in the after torpedo room, would eliminate exposure a great deal of exposure of the forward impulse bottles could be eliminated by placing them in a horizontal position rather than vertical outside the pressure hull.

F. Exterior Hull above Waterline.

(a) Condition and cause of damage to.

SECRET

USS SKATE (SS305)

1. Pressure hull and framing - no visible damage has been found to the pressure hull and framing.
2. Bow framing - Bow framing forward of frame 17 is intact.
3. Stern framing - Stern framing aft of frame 132 is fractured along the later line.
4. Welding - Superstructure welding held in most places throughout the length of the superstructure, the metal tearing adjacent to the welding.
5. Structural castings - Intact.

(b) Constructive criticism of design and construction.

A heavier, lower, more stream-lined design might stand up better.

G. Compartments.

- (a) Damage to shell, bulkheads and framing and causes - None.
- (b) Damage to jincer bulkheads, decks, and floor-plates and causes - None.
- (c) Damage to access closure and cause - None.
- (d) Damage to hull fittings and equipment and causes - None.
- (e) Damage to foundations, shock mounts and sound mounts and causes. The TBL radio transmitter in the radio room partially tore away from its mounting bracket. It is believed that this resulted from a big roll to starboard which the ship apparently made under the pressure of the blast.

SECRET

USS SKATE (SS305)

(f) Evidences of fire - None.

(g) Damage to watertight integrity and causes -  
There was no damage to water tight integrity.

(h) Estimate of reduction in watertight subdivision,  
habitability and utility of compartments and casualties to  
personnel sealed in the boat - None.

(i) Constructive criticism as to design or con-  
struction - None.

H. Armor Decks.

None fitted.

J. Underwater Hull.

(a) Condition and causes of damage to.

1. Pressure hull plating and framing - There  
was only one slight indication of damage. There was a narrow  
crack about three inches long between the pressure hull and the  
after side of frame 55. Frame 55 serves as the foundation for  
the after end of the conning tower, and it is believed that the  
force of the blast against the conning tower tended to separate  
the frame from the hull plating.

2. Bow framing - None.

3. Stern framing - Aft of the torpedo tube  
nozzles, the stern was displaced several inches to starboard.

4. Structural castings - None.

5. Struts and stern tubes - None.

6. Rudders and planes - None

7. Keels - None

SECRET

USS SKATE (SS305)

8. Miscellaneous fittings - None

(b) Effect of damage on.

1. Buoyancy - Reserve buoyancy was temporarily decreased by the flooding of main ballast tanks 2B, 2C, 2D, 6B, 6C and 7.

2. Operability surfaced and submerged - Surface operability was only slightly impaired. All means of taking bearings were either demolished or rendered useless. It is believed that the SKATE could dive. Bow and stern planes function normally. The only item remaining undamaged of the ship's "eyes and ears" (periscopes, sound gear, radar) is the JK-QC sound gear.

3. Maneuverability and resistance - Surface maneuverability was not affected. In a trial on 8 July, a speed of 17 knots by bendix log was attained. Submerged maneuverability and resistance would undoubtedly be affected by the irregular shape of the wreckage topside.

(c) Constructive criticism as to design or construction - No changes recommended.

K. Tanks.

(a) Condition and causes of damage to.

1. Exterior tanks - There was only minor damage to exterior tanks. One place along the tank tops, port side, was dished in to a depth of about six inches. As this occurred only in one place it is believed this was caused either by a heavy falling object or by the blast being focused by the gun sponson which formerly overhung the tank top at the dished in place.

2. Interior tanks - No damage.

SECRET

USS SKATE (SS305)

(b) Leakage and cause for all tanks - MBT 2D 10# blow line was ruptured between the stop valve and the vent riser. MBT's 2B, 2C, 6B, and 6C vented slowly through damaged salvage connections. MBT 7 main vent was damaged, apparently by the after capstan being forced against it.

(c) Constructive criticism as to design, construction or location - Salvage fittings are the weakest fittings on the MBT's. Main vents should be more adequately protected. 10# blow line could be placed inside the pressure hull.

L. Flooding.

(a) Description of major flooding areas. No interior flooding occurred.

(b) Sources of flooding - None.

(c) List of compartments or tanks believed to have flooded slowly so as to be susceptible to damage control - MBT 2B, 2C, 6B, and 6C.

(d) Constructive criticism as to design or construction - None.

M. Ventilation.

(a) Condition and causes of damage to.

1. Hull and battery ventilation system outboard-  
The major damage to the hull ventilation system outboard was to the main induction valve. The housing was distorted and moved over to starboard about 18 inches. The operating rod extending through the hull was sheared off. The valve gasket and seat were undamaged as was the piping branching out from the main valve housing.

2. Engine induction system - The forward engine room induction piping (port) was moved to starboard several inches

SECRET

USS SKATE (SS305)

and was cracked near where it enters the engine room. The piping on the starboard side was intact.

3. Ventilation system inboard - None.

(b) Evidences that ventilation system conducted heat, blast, fire, smoke or water into any compartment - None.

(c) Constructive criticism of design or construction-  
The main induction valve assembly needs a stronger foundation.

N. Ship Control and Fire Control Stations.

(a) Damage to control stations due to failure of compartment boundaries - The bridge was demolished. The conning tower, control room and maneuvering room were intact.

(b) Constructive criticism of layout, arrangement, and protection - No conventional bridge could have withstood the blast the SKATE's received.

O. (Combined with Item N.)

P. Ammunition Stowage.

(a) Condition and causes of damage to.

1. Ready service stowage - Ready service lockers were undamaged except for bent door operating mechanisms. Two 40MM ammunition stowages were missing. The after 5" ready locker was moved slightly from its original location when its foundation was demolished. The S.P. samples and ammunition inside the lockers appeared to be in good condition and temperatures were normal.

2. Magazines - None.

3. Constructive criticism as to location, protection performance, and design or construction - Present design appears satisfactory.

SECRET

USS SKATE (SS305)

**Q.      Ammunition Handling.**

(a) Condition, operability and causes of damage to.

1. Passing scuttle - Intact.

2. Torpedo loading cradles - The torpedo loading cradles topside were both missing.

3. Torpedo loading derrick - The torpedo loading derrick was stowed in the superstructure, port side, forward of the forward torpedo room hatch. The stanchien, the boom and the sheave were badly bent. The derrick is damaged beyond repair, direct cause not apparent as it was in a sheltered place.

(b) Constructive criticism of design construction or location - None.

**R.      Strength.**

(a) Details of any damage to and causes of damage to.

1. Pressure hull plating including conning tower -  
None.

2. Pressure hull framing - None

3. Main bulkheads - None.

4. Welding or other joints - There was only one slight indication of damage. There was a narrow crack about three inches long between the after side of frame 55 and the pressure hull. Frame 55 serves as the foundation for the after end of the conning tower, and it is believed that the force of the blast against the conning tower tended to separate the frame from the hull plating.

5. Structure in way of discontinuities - None.

SECRET

USS SKATE (SS305)

(b) Constructive criticism - Non

S. Miscellaneous.

T. Coverings.

(a) Condition and cause of damage to.

1. Paint - Exterior topside scorched on surfaces toward blast. Exterior below waterline no damage. Interior, no damage.

2. Galvanizing, plating, etc. - No damage

3. Linoleum - No damage.

4. Cork insulation - No damage.

U. Welding and Rivetting.

(a) General summary of welding performance - Pressure hull and outer hull welding withstood the blast without apparent effect except as noted under Items "J" and "R". In the superstructure, fractures generally occurred along pipes, frames and plates rather than at the welds.

(b) General summary of rivet performance - The riveted "hard patches" showed no apparent effect.

(c) Constructive criticism - None.

SECRET

USS SKATE (SS305)

Page 116 of 140 Pages

COMMANDING OFFICER REPORT

PART III

SECTION II - MACHINERY

A. General Description of Machinery Damage.

- (a) Overall condition - Good below decks.
- (b) Areas of major damage - All topside machinery.
- (c) Primary causes of damage in each area of major damage - Blast effect.
- (d) Effect of Target Test on overall operation of machinery plant - None.

B. Boilers.

Not Applicable.

C. Boilers.

Not Applicable.

D. Fuel Oil Equipment.

- (a) Heaters - No damage.
- (b) Strainers - No damage.
- (c) Manifolds - No damage
- (d) Fittings (thermometers, gages) - Pressure gages to expansion and collecting tank are out of calibration. No other damage to thermometers and gages.
- (e) Flexible fueling hose - No damage.

SECRET

USS SKATE (SS305)

E. Boiler feedwater equipment.

Not Applicable.

F. Main Propulsion Machinery.

(a) Main and auxiliary engines.

1. Foundations - No change.

2. Casings and cylinders - No change.

3. Bearings, crankshafts, pistons, etc. - No change

4. Couplings - No change.

5. Fuel injection system - No change

6. Superchargers - No change.

7. Governors - No change

8. Inboard and outboard exhaust valves - No change to inboard exhaust valves. No change to starboard outboard exhaust valves, #1 and #3. Port outboard exhaust valves, #2 and #4 are stiff to operate because the operating mechanism has been knocked slightly out of line. The auxiliary engine out board exhaust valve operates properly but its operating mechanism shaft has been bent.

9. Mufflers and exhaust piping - No change to #1 and #3 mufflers. #2 and #4 mufflers are missing. The auxiliary muffler was torn from its foundation and is inoperative. Exhaust piping on #4 engine has small leak outside pressure hull.

10. Cooling system - No change to cooling system below decks. Cooling system to exhaust valves and mufflers topside badly mangled. Lines were twisted and torn from the blast effect.

SECRET

USS SKATE (SS305)

G. Reduction Gears.

- (a) Foundations and casings - No change.
- (b) Gears and shafting. - No change.
- (c) Bearings - No change.
- (d) Couplings (flexible and solid) - No change.
- (e) Fittings (oil sights, thermometers, etc.) No change.
- (f) Turning gears - No change.

H. Shafting and Bearings.

- (a) Shafting - No change.
- (b) Bearings and bearing foundations - No change.
- (c) Alignment - No change in alignment to starboard shafting. Port shafting but about .020 at after coupling.
- (d) Hull packing gland - No change.
- (e) Thrust bearings - No change.
- (f) Strut bearings - No damage to strut bearings noted during inspection by diver, however, vessel has not been drydocked for inspection.

I. Lubrication System.

- (a) Coolers - No change.
- (b) Filters and strainers - No change.
- (c) Purifiers - No change.

SECRET

USS SKATE (SS305)

Page 119 of 140 Pages

(d) Tanks (sump, settling etc.) - No change.

(e) Fittings (gauges, etc.) - No change.

J. Condensers and Air Ejectors.

Not Applicable.

K. Pumps.

(a) Booster drain pump - Not applicable.

(b) Circulating pumps - No change.

(c) Trim pump - No change

(d) Drain pump - No change

(e) Priming pumps - Not applicable.

(f) Fuel oil pumps - No change.

(g) Lubricating oil pumps - No change.

(h) Distiller feed pump - No change

L. Auxiliary Generators.

Discussed under Item F (Main Propulsion).

M. Propellers.

(a) Blades - No change.

(b) Caps, nuts, etc. - No change

N. Distilling Plant.

(a) Distillers - No change.

SECRET

USS SKATE (SS305)

(b) Compressors - No change.

(c) Miscellaneous valves fittings, gages, attached piping, etc. - No change.

O. Refrigerating and air conditioning plants.

(a) Compressors - No change.

(b) Motors - No change.

(c) Condensers - No change.

(d) Foundations - No change.

(e) Refrigerant piping and cooling coils - No change.

(f) Insulation and lagging - No change.

(g) Miscellaneous valves, switches, controls, fittings, etc. - No change.

P. Winches, windlasses, and capstans.

(a) Foundations and bed plates - No change forward.  
After foundation demolished.

(b) Brakes and brake lining - No change forward.  
Not applicable aft.

(c) Gearing - No change forward. Aft shaft bent forward so drum bears against #7 main vent.

(d) Drums, bearings, shafting - No change forward.  
Demolished aft.

(e) Hydraulic systems - No change forward. Not applicable aft.

(f) Fittings, valves, etc. - Chain marker missing to windlass. All fittings missing aft.

SECRET

USS SKATE (SS305)

Q. Steering and Diving.

- (a) Steering rams and cylinders - No change.
- (b) Hydraulic systems including pumps piping, etc. -  
No change.
- (c) Bow plane rigging mechanism - No change.
- (d) Bow plane tilting mechanism - No change.
- (e) Stern plane tilting mechanism - No change.
- (f) Foundations - No change.
- (g) Miscellaneous (steering stands, valves, gages, etc). - No change.

R. Elevators, Ammunition Hoists, Etc.

Not Applicable.

S. Ventilation (Machinery)

- (a) Battery ventilation blowers - No change.
- (b) Battery air flow meters - No change.
- (c) Hull supply and exhaust blowers - No change.
- (d) Engine air and ventilation induction hull valves and mechanisms - No change.
- (e) Bulkhead flappers - No change.
- (f) Foundations and mountings - No change.
- (g) Fans and motors - No change.

SECRET

USS SKATE (SS305)

T. Compressed Air Plant.

- (a) High pressure air compressors - No change.
- (b) Low pressure blowers - No change.
- (c) Foundations - No change.
- (d) Coolers - No change.
- (e) Air banks - No change.
- (f) Torpedo impulse flasks - No change.
- (g) Miscellaneous gages, attached piping, etc. - No change

U. Diesels.

Not Applicable. See Item F.

V. Piping Systems.

- (a) High pressure (3000 lb.) air piping - No change.
- (b) Main ballast tank blow (600 lb.) air piping -  
No change.
- (c) Service (200 lb.) air piping - No change.
- (d) Main ballast tank blow (10 lb) air piping - The following lines badly damaged. 2D carried away at riser. 6B carried away at riser. 6D broken in two places over for'd engine room. 7 carried away. All others intact.
- (e) Torpedo impulse air piping - Lines to 4 and 6 broken and carried away. All others intact.
- (f) Engine air starting piping - No change.

SECRET

USS SKATE (SS305)

- (g) Engine shut-down air piping . - No change.
- (h) Salvage air piping - For'd torpedo room high salvage slightly bent. For'd battery low salvage slightly bent, cap broken off top. For'd battery high salvage slightly bent. Control room low salvage slightly bent, cap missing. Line also bent. Low salvage missing. For'd engine room hight salvage missing. For'd engine room low salvage bent. Aft engine room high salvage cap missing. Aft. engine room low salvage missing. Maneuvering room high and low bent. Aft torpedo room high missing. All valves operative, damage was above all valves. 1MBT slightly bent. 2A slightly bent. 2B line missing above valve. 2D valve missing. Safety badly bent. 6A and B missing. All other intact.
- (i) Main ballast tank vent piping - 2C and 2D vent risers dented. 2D vent riser holed by low pressure line carrying away
- (j) Hull and battery ventilation piping - No change.
- (k) Trimming system piping - No change.
- (l) Drain system piping - No change.
- (m) Magazine flooding piping - No change.
- (n) Plumbing piping - No change.
- (o) Fuel oil piping - No damage except both topside filling lines carried away.
- (p) Fuel oil compensating piping - #2 main engine and auxiliary engine outboard exhaust valve discharge to compensating water line carried away. Compensating line from expansion tank forward completely damaged including gooseneck. All other compensating piping intact.
- (q) Lubricating oil piping - Filling connection carried away. Rest intact.

SECRET

USS SKATE (SS305)

(r) Hydraulic system piping - Normal except periscope and radar mast piping bent.

(s) Engine cooling salt water piping - #2 and auxiliary engine discharge lines to outboard exhaust and mufflers carried away. Discharge line from #4 outboard exhaust to muffler carried away. All topside cooling water lines are holed. All inboard lines intact.

(t) Engine cooling fresh water piping - No change.

(u) Main motor cooling salt water piping - No change.

(v) Distiller feed piping - No change.

(w) Refrigeration circulating water piping - No change.

(x) Freon piping and coils - No change.

(y) Air conditioning circulating water piping - No change.

(z) Air compressor circulating water piping - No change.

(aa) Potable fresh water piping - No change.

(bb) Battery water piping - No change.

## W. Hydraulic System.

(a) Main hydraulic pump - No damage.

(b) Hydraulic accumulator - No damage.

(c) Main vent hydraulic operating mechanisms - No damage.

(d) Ballast tank flood valve hydraulic operating mechanisms - No damage.

(e) Engine air induction valve operating mechanism - The operating mechanism below decks was intact, but the operating

SECRET

USS SKATE (SS305)

rod was broken above where it passes through the pressure hull.

(f) Ventilation induction valve operating mechanism - The operating mechanism below decks was intact, but the operating rod was broken above where it passes through the pressure hull.

(g) Main engine exhaust valve operating mechanism - No damage.

(h) Auxiliary engine exhaust valve operating mechanism - No. 2 and 4 main engine exhaust valves were pushed over to starboard. Because of this misalignment, the valves will only open seven eights of the way. The hydraulic gear in the engine rooms is intact.

(i) Sound head lower/rise mechanism - No damage.

(j) Hydraulic hand pump for sound heads - No damage.

(k) Hydraulic periscope lower/raise mechanism - All hydraulic lines above the conning tower carried away and the periscopes are bent enough to prevent any movement.

(l) Hydraulic SD/SV radar mast lower/raise mechanism - Same as (k).

(m) Bow plane hydraulic tilting mechanism - No damage.

(n) Stern plane hydraulic tilting mechanism - No damage.

(o) Bow plane hydraulic rigging mechanism - No damage.

#### X. Navigational Instruments.

(a) Underwater log - No damage.

(b) Magnetic compasses - No damage.

#### Y. Periscopes.

(a) Optics, bearings, train, stadimeter, etc. - The periscopes are in the fully lowered position and cannot be moved as

SECRET

USS SKATE (SS305)

they are bent about 10° to starboard at a point some none feet from the upper ends. Both upper windows are intact. The prisms in No. 2 are shattered. No. 1 scope is not high enough to observe the prisms.

(b) Hoist mechanism - All hydraulic lines above the conning tower carried away.

Z. Radar and Sonar.

(a) Hoisting mechanism - All hydraulic lines topside carried away.

(b) Training mechanism - All sonar training mechanisms are intact although the QB head cannot be trained as the shaft was bent when the ship was beached. The SJ radar training mechanism is intact, but the antenna cannot be trained because the vertical wave guide was bent with the periscope shears.

SECRET

USS SKATE (SS305)

Page 127 of 140 Pages

## COMMANDING OFFICERS REPORT

### SECTION III

#### ELECTRICAL

##### A. General Description of Electrical Damage.

(a) Overall Condition - Good below decks.

(b) Areas of major damage - External wiring.

(c) Primary causes of damage in each area of major damage  
Blast effect.

(d) Operability of electric plant - Good.

1. Electrical Propulsion - Normal.

2. Main storage batteries - Normal.

3. Auxiliary power - Normal.

4. Communications - Normal except bridge  
reproducers 1 and 7 MC missing.

5. Fire control circuits - Normal except for  
gyro setting aft.

6. Lighting - Normal except for running and  
stern lights.

7. Ventilation - Normal.

(e) Types of equipment most affected.

1. Switchboards and switchgear. Normal except  
for after power breaker being knocked out in maneuvering room.

2. Rotating machinery - Normal.

SECRET

USS SKATE (SS305)

Page 128 of 140 Pages

3. Motor controllers - Normal.

4. Cables and supports - Good below decks.

B. Electric Propulsion Rotating Equipment (Propulsion motors, propulsion generators, submarine auxiliary generators, excitors, motor generator sets).

- (a) Frame and mountings - Intact.
- (b) Communtator or slip rings - Intact.
- (c) Brushes and brush rigging - Intact.
- (d) Bearings - Intact.
- (e) Fans or blowers - Intact.
- (f) Internal lighting fixtures - Intact.
- (g) Air coolers and filters - Intact.

C. Electric Propulsion Control Equipment (Propulsion control cubicles, transfer switch panels, controllers for motor-generator sets.)

- (a) Framework and mountings - Intact.
- (b) Electrical connections and wiring - Intact.
- (c) Busbars - Intact.
- (d) Contactors, switches and relays - Intact.
- (e) Rheostats and resistors - Intact.
- (f) Mechanical operating mechanisms and interlocks - Intact.
- (g) Insulating materials - Intact.

SECRET

USS SKATE (SS305)

(h) Instruments - No damage.

(i) Fuses - Intact.

(j) Rectifiers - Not applicable.

(k) Regulators - All regulators out of adjustment.  
Does not effect operability due to manual control.

D. Generators - Ships Service.

See Item K.

E. Generators - Emergency.

Not Applicable.

F. Switchboards. Distribution and Transfer Panels (Ships Service, Emergency, Battery Charging, Lighting and Test Switchboards - Power and Lighting Distribution Panels - Submarine Torpedo Heating and Hydrogen Burning Panels - Transfer Panels - Degaussing Panels).

(a) Framework and Mountings - Intact.

(b) Electrical connections and wiring - Intact.

(c) Busbars - Intact.

(d) Circuit breakers, contactors, switches and relays - Intact.

(e) Rheostats and resistors - Intact.

(f) Mechanical operating mechanisms and Interlocks - Not applicable.

(g) Insulating materials - Intact.

(h) Instruments - No damage.

SECRET

USS SKATE (SS305)

Page 130 of 140 Pages.

(i) Rectifiers - Not applicable.

(j) Fuses - Intact except for fuses knocked out of clips in feeder box in aft. engine room and control room.

(k) Voltage regulators - All regulators out of adjustment. Does not effect operability due to manual control.

G. Wiring, Wiring Equipment, and Wireways.

(a) Cable (Power, lighting, I.C., F.C., propulsion and degaussing - All intact, degaussing not applicable.

(b) Wireway supports - Intact.

(c) Connection, Junction boxes, receptacles, and plugs - Intact.

H. Transformers (Lighting and I.C.)

(a) Framework and mountings - Not applicable.

(b) Electrical connections - Not applicable.

I. Submarine Propelling Batteries.

(a) Jars - Intact.

(b) Covers, - Nine missing.

(c) Wedges and strongbacks - Loose.

(d) Busbars and cell connections - Intact.

(e) Acid spillage - None.

J. Portable Batteries.

Not Applicable.

SECRET

USS SKATE (SS305)

Page 131 of 140 Pages

K. Motors, Motor Generator Sets, and Motor Controllers  
(Motor and controllers for engine room auxiliaries, steering gear, deck auxiliaries, air conditioning and refrigeration, ventilation, distilling equipment, etc. - Motor generator sets for lighting, battery charging, interior communications, etc.)

(a) Rotating Equipment.

1. Framework and mounting - Intact.
2. Commutator or slip rings - Intact.
3. Brushes and brush rigging - Intact.
4. Bearings - Intact.
5. Speed regulators - out of adjustment.

(b) Control Equipment.

1. Framework and mounting - Intact.
2. Electrical connections and wiring - Intact.
3. Contactors, switches and relays - Intact.
4. Rheostats and resistors - Intact.
5. Insulating materials - Intact.
6. Pilot circuit devices - Intact.
7. Brakes - Broken.

L. Lighting Equipment.

(a) Lamps (Rough service, rough service high impact and fluorescent lights) - No damage.

SECRET

USS SKATE (SS305)

- (b) Reflectors - Intact.
- (c) Fixture mounts - Intact.
- (d) Shock mounts (U-strap type and plate type)- Intact.
- (e) Pendant lamp holders - Not applicable.
- (f) Lamp globes - Not applicable.

M. Searchlights (36", 24", 12" and 8").

12" and 8" stowed in conning tower.

- (a) Framework and mountings - Intact.
- (b) Front glass - Intact.
- (c) Shutter and operating mechanism - Intact.
- (d) Locks and brakes - Not applicable.
- (e) Arc lamp feed rods - Not applicable.
- (f) Incandescent lamps - Intact.
- (g) Rheostats - Not applicable.

N. Degaussing Equipment .

Not Applicable.

O. Gyro Compass Equipment.

(a) Master - Panel intact. Mercury spilled from oscillating bowl, sensitive element out of balance due to mercury spilled. Vacuum down to 15" in south rotor.

(b) Repeaters - All repeater intact except that cables to bridge repeater were cut and grounded.

SECRET

USS SKATE (SS305)

(c) DRT and DRA - Intact.

P. Sound Powered Telephones.

(a) Headsets - Intact.

(b) Handsets - Intact.

(c) Jack and switch boxes - Intact except for external connections missing.

(d) Stowage - Intact.

Q. Ships Service Telephones.

(a) Exchange - Intact.

(b) Line equipment - Intact.

R. Announcing Systems.

(a) Portable (PAM and PAB) - Not applicable.

(b) Amplifier racks - Not applicable.

(c) Control racks - Not applicable.

(d) Transmitting station - Intact except for bridge.

(e) Reproducers - Intact except for bridge.

(f) Inter-communication units - Intact except for bridge.

S. Telegraphs

Intact.

T. Indicating Systems.

Intact except for rudder angle indicator on bridge.

SECRET

USS SKATE (SS305)

U. I.C and A.C.O. Switchboards.

Intact.

V. F.C. Switchboards.

Intact.

SECRET

USS SKATE (SS305)

Page 135 of 140 Pages

COMMANDING OFFICER REPORT

PART III

SECTION IV - ELECTRONICS

A. General Description of Electronics Damage.

(a) Overall condition - with the exception of antennae topside, superstructure antennae leads, and topside sound heads, the electronics equipment shows little damage. The starboard sound head, left lowered for the test, was damaged by beaching. Shock mounts on heavy equipment failed. All gear contained by the pressure hull is operable.

(b) Areas of major damage. - All topside gear was heavily damaged, requiring complete replacement.

(c) Primary cause of damage in each area - The blast of the bomb evidently caused all topside damage, although many leads running through the superstructure and antennae trunk insulators were damaged when the superstructure carried away.

(d) Operability of electronics equipment.

1. Radar - Operable except for lack of antennae.

2. Radio - Operable except for lack of antennae.

3. Sonar - Operable except for lack of JP and QLA sound heads topside and badly damaged QB head.

(e) Types of equipment most affected - Equipment with antennae or projectors topside was rendered inoperable by the bomb.

SECRET

USS SKATE (SS305)

B. Fire Control Radar.

ST radar gear is operable except for damage to number one periscope which makes the radar antennae inaccessible. Transmitter, receiver, and associated gear is intact. Shock mounts of gear located in conning tower were damaged by the roll of the ship.

C. Surface Search Radar.

SJ radar gear is operable except for damage to antennae caused by blast. The wave guide is bent, reflector torn out of position and training mechanism in conning tower damaged due to wave guide being torn from foundation and pulled out by the bomb. The training motor is intact, transmitter, receiver, and associated gear is intact. Shock mounts of gear in conning tower sustained secondary damage due to roll of the ship.

D. Air Search Radar.

The SD radar antennae was blown away by the bomb the antennae mast was bent and rendered inoperable. Transmitter, receiver, and associated gear is intact.

E. Radar Repeaters.

Not Applicable.

F. Radar Counter Measures Equipment.

Removed from ship prior to Test "A".

G. Radar and Radio Beacons.

Not Applicable.

H. IFF Equipment.

This gear was disassembled prior to test Able and antennae removed. Units still aboard are intact.

SECRET

USS SKATE (SS305)

I. Communication Transmitters (Radio).

The TBL transmitter was torn from its foundations by probable roll of the ship, causing bent facings. Otherwise it is intact and operable.

J. Communication Receivers (Radio)

Intact.

K. Communication Antennae (Radio)

All were blown away by the blast, leads in antennae trunk were grounded when stand-off insulators were broken. The lead to the whip antennae was damaged, probably by the superstructure when it carried away. Antennae trunk water dam was shattered and antennae trunk flapper valve was jarred open by the blast.

L. Radio Transceivers (Combined Transmitters and Receivers).

Intact.

M. Sonar Echo Ranging and Listening Equipment.

The QLA-5 projector, mounted topside, was bent to starboard and forward, the shaft broken 300 degrees of its circumference about two inches below the flange by the blast. The shaft apparently is distorted because training gears below are out of mesh. The QLA stack was torn from its shock-proof mounts by the roll of the ship, partly due because the upper support was not properly secured. The JP projector was blown over the side, receiver intact. JK-QC is intact. The QB head, left lowered for the test, was badly damaged by grounding, therefore any damage which might have been caused by the bomb is unknown. The projector face is pulled off and the shaft bent, the shaft was pushed up, evidently by grounding, which caused the locking devices to be sprung also damaging the locking device roller path on the shaft. The head cannot be locked in lowered position and cannot be raised

SECRET

USS SKATE (SS305)

beyond a foot (normally housed by raising approximately four feet). The training mechanism is intact. All sound stacks in the forward torpedo room, except the QLA foundations, are intact. The sound stacks in the conning tower are intact except for the QB repeater which had fallen out of its frame, probably due to the roll of the ship. This caused the connecting leads to be broken. The hinged bracket which secures this repeater to the frame had been damaged previously and the inertia of the repeater apparently caused the bracket to spring open. This permitted the repeater to fall out of the sound stack frame. The TDM recorder cover was jarred open presumably by the blast and the paper fell out, no damage. Unable to test TDM recorder cover was jarred open presumably by the blast and the paper fell out, no damage. Unable to test TDM because of damaged QB head.

N. Sonar Echo Sounding Equipment and Altimeters.

Intact.

O. Loran Navigation Equipment.

Intact except for antennae and leads in superstructure blown off by bomb.

P. Power Supplies (Motor Generators and Filters).

Intact.

Q. Television and Teletype Equipment.

Not Applicable.

R. Test Equipment (including frequency meters).

Intact.

S. Instrumentation.

None.

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USS SKATE (SS305)

T. Telephone Equipment.

Intact.

U. Direction Finder (Radio).

Not Applicable.

V. Spare Parts.

Intact.

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USS SKATE (SS305)

Page 140 of 140 Pages

Classification (C-~~3~~) (Changed to **CONFIDENTIAL**)  
By Authority of Joint Chiefs of Staff (AS100.15 APR 49)  
By John Beggs Capt Date 1 May 51  
AFSWP

**CONFIDENTIAL**



**Defense Special Weapons Agency**  
6801 Telegraph Road  
Alexandria, Virginia 22310-3398

TRC

9 April 1997

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER  
ATTENTION: OMI/Mr. William Bush

SUBJECT: Declassification of Reports

The Defense Special Weapons Agency (formerly Defense Nuclear Agency) Security Office has reviewed and declassified the following reports:

+ ST-A

AD-366748 -	XRD-65
AD-366747 -	XRD-64
AD-366746 -	XRD-63
AD-376826 -	XRD-60
AD-376824 -	XRD-58
AD-376825 -	XRD-59
AD-376823 -	XRD-57
AD-376822 -	XRD-56
AD-376821 -	XRD-55
AD-366743 -	XRD-54
AD-376820 -	XRD-53
AD-366742 -	XRD-52
AD-366741 -	XRD-51
AD-366740 -	XRD-50-Volume-2
AD-366739 -	XRD-49-Volume-1
AD-366738 -	XRD-48
AD-366737	XRD-47

TRC

9 April 1997

SUBJECT: Declassification of Reports

AD-366736 -	XRD-46
AD-366735 -	XRD-45
AD-366723 -	XRD-37
AD-366721 -	XRD-35
AD-366717 -	XRD-31-Volume-2
AD-366716 -	XRD-30-Volume-1
AD-366751 -	XRD-68-Volume-2
AD-366750 -	XRD-67-Volume-1
AD-366752 -	XRD-69
AD-366744 -	XRD-61.

All of the cited reports are now **approved for public release**. **Distribution statement "A"** now applies.

*Ardith Jarrett*  
ARDITH JARRETT  
Chief, Technical Resource Center

*Completed  
1 Mar 2000  
B.W.*